A DISCUSSION OF GRAZING MANAGEMENT SYSTEMS AND SOME PERTINENT LITERATURE (ABSTRACTS AND EXCERPTS); 1895 - 1966

WOOD · WATER · FORAGE · WILDLIFE · RECREATION
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A DISCUSSION OF GRAZING MANAGEMENT SYSTEMS

and

SOME PERTINENT LITERATURE

(Abstracts & Excerpts) 1895-1966

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Introduction

The subject of grazing management dates back to antiquity and appears to have been a problem in Biblical times. Reference to English literature on grazing management dates to the early 1600's, and a rotation grazing system was described in 1797.[1] Pieters[2] dated his review of pasture research literature in North America to 1855. For this handbook, the year 1895 was selected since it is felt that Jared Smith's publicized accounts of range deterioration and natural rest-rotation grazing provided the impetus for early research in the United States.

1. Johnstone - Wallace, D. B. and Keith Kennedy. 1944. Grazing Management Practices and Their Relationship to the Behavior and Grazing Habits of Cattle. Jour. Agr. Sc. 34(4):190-197.

2. Pieters, A. J. 1936. A Digest of Pasture Research Literature in the Continental United States and Canada, 1855 to 1935. U.S.D.A., Bureau of Plant Industry, 130 pages.

Overgrazing and subsequent range deterioration are problems created by man. Areas of high precipitation having generalized storms developed deep, rich soils and were the first to be converted to farming operations. Areas of lower precipitation generally characterized by localized storms were left to grazing by wild animals and subsequently were utilized by domestic livestock. Prior to man's confinement of domesticated grazing animals and the restriction of wild animal movement, the open range was utilized in a natural deferred-rotation system of use. Unrestricted animals were able to follow the rains and obtain fresh green forage. They were also free to leave drier areas and thus provide needed rest. This phenomena could still be observed in certain areas of the Western United States prior to World War II and may still be observed in certain areas of the Far East, South America, and Africa.

In 1895, Jared Smith described the 500,000,000 acres of the prairie region of the United States as follows:

> "The prairies in their wild state were covered with the richest possible grass flora. There was no similar region that had so many useful species and so few poisonous or injurious ones. Almost any square mile of the whole extent of territory could furnish in one season 50 kinds of grasses and native forage plants, grasses that would make from one and a half to two tons of hay per acre as rich as that from an Old World meadow.
>
> "Less than thirty years ago, 4,000,000 buffaloes and countless numbers of wild horses roamed unrestricted over the region in question (Southwest), gradually moving northward as the

season advanced, returning southward at the approach of winter. This natural movement of the stock permitted alternation of pasturing and rest for the land, resulting in the maintenance of the forage supply; in fact, it was an ideal method of fostering and improving these pasture lands which covered nearly 200,000 square miles of country." (Smith, 1899).

Man's restriction of the movement of grazing animals confined them to sites subject to the vagaries of localized storms and periodic drouth. His inability to determine grazing capacity or rapidly change animal numbers to meet prevailing conditions led to either periodic or continuous overgrazing. In either case, the end result was an early or eventual decline in range productivity. This necessitated reductions in stocking rates and the organized movement of animals under some form of grazing management system.

"Ideal range management would mean the utilization of the forage crop in a way to maintain the lands at their highest state of productiveness and at the same time afford the greatest possible returns to the stock industry. It is obvious that the requirements of the vegetation and the requirements of the stock are to a great extent antagonistic." (Sampson, 1914).

Objectives

This handbook has been compiled to provide the land manager with easy access to some pertinent literature on grazing management. Most land managers are hampered in this respect due to:

1. Unavailability of literature.
2. Diversity of publication sources.
3. Limited access to agricultural libraries.
4. Limited editions of material.
5. Age of the publications.

For these reasons, solutions to the problems of the land manager have become more elusive. When restricted to a limited amount of literature, the land manager is more apt to be misinformed than uninformed. Conclusions of any given article or study may be influenced by:

1. Author viewpoint--from the standpoint of the land manager, all aspects of the grazing business (soils, vegetation, ecological stage of plant succession, animal response, and economics) must be considered. However, the background or profession of the author may limit the conclusions to a single aspect.

2. Radical departures from accepted practices which sometimes receive broad distribution or undue publicity. Frequently the land manager lacks access to other literature on the same subject for purposes of comparison.

3. Duration of study--conclusions have been based, in a few cases, on studies of such short duration that many aspects of the grazing business could not be properly evaluated.

4. Intensity of grazing--frequently grazing system studies were combined with rate of grazing studies. In some cases all rates of grazing were too high and other aspects of the study were obscured by this fact.

5. Lack of measurements--in a few cases, conclusions have been reached by the author concerning all aspects of the business, while actual measurements have been made on only one or two aspects.

6. Source of literature--most grazing management literature has been written by faculty members of colleges or universities, or by employees of various governmental agencies. When evaluating the conclusions of a given article, it frequently behooves the reader to be aware of the basic philosophies and objectives of the source.

For these reasons, it is important to read the entire article. However, many managers only read the summary or conclusions which in some cases fail to bring out these factors.

Finally, information concerning a given grazing system is limited in quantity for any given area. In order to function to the best of his ability, the land manager should have at his disposal not only information concerning his particular area, but also that for other regions.

Although the extrapolation of information from one area to another is not always practical or desirable, when sensibly applied it may be useful as a guide to the practicality of a given system under a given set of conditions.

> "Scientific range management is dependent upon the application of knowledge from various fields to the production of livestock. As complete information as possible is needed about the composition of the vegetation, the life histories and habits of the most important species constituting the vegetation, the relations of the most important species to environmental influences including grazing, the needs and habits of livestock, water resources, relation of topographic and climatic conditions to livestock, and the economic conditions affecting the production and sale of livestock. These seven fields may be considered basic factors in range management."
> (Hanson, et al, 1931)

Discussion

One-hundred fifteen papers on grazing management were reviewed and either abstracted or excerpted. These abstracts and excerpts are longer than usual so as to provide as much information as possible concerning the climate, vegetation, soils, and experimental design, if any, of each paper. They were then categorized for the convenience of the land manager as follows:

1. Historical or Background Papers (15) - These are largely earlier papers which focused attention on the problems of grazing management and provided the impetus to research on grazing management systems.

2. Research Study Papers (49) - These break down as follows:

a.	Two pasture rotation or "alternate grazing"	18
b.	Three pasture rotation	11
c.	Four or more pasture rotation	3
d.	Deferred grazing	10
e.	Rest-rotation grazing	6
f.	Deferred-rotation grazing	4
		52*

3. Evaluation Studies (17) - These are mostly the more recent popular article type papers.

Six of these fit two of the five categories and are listed twice. They are usually large-scale, evaluation type studies with conclusions based on allotment analyses, vegetation resource surveys, soils surveys, or observations and ranch records.

4. Papers Pertinent to Grazing Management (25) - These are generally studies or discussions of some pertinent phase of grazing management. These papers should be of benefit in preparing management plans for a given range.

5. Informative Papers (15) - These are discussions or literature reviews of a particular grazing system or pertinent phase of management related to grazing systems.

The practical range manager is interested in obtaining certain information from any given study. For the purpose of extrapolating results to his particular work area, he wants to know: Age and class of livestock used; size and duration of study; measurements taken on vegetation, soils, and animal response; and a description of the vegetation, climate and soils of the study site. These data were summarized as follows for the 49 studies:

*(Three of the studies tested two systems simultaneously.)

1. Type of livestock used in the experiments

a.	Type, age and class not given	11	studies
b.	Dairy cattle, mixed	2	"
c.	Dairy cows	2	"
d.	Steers, no age given	7	"
e.	Steers, mixed ages	2	"
f.	Steers, two year olds	4	"
g.	Steers, yearling	3	"
h.	Steers and heifers mixed	2	"
i.	Heifers, yearling	1	"
j.	Cows and calves	6	"
k.	Calves	1	"
l.	Sheep, no age and class given.............	6	"
m.	Cows and sheep	1	"
n.	Cows, sheep, and goats	1	"

2. Pasture size used in the experiments

a.	Size not given	15	studies
b.	Under 5 acres	5	"
c.	Under 25 acres	10	"
d.	Under 75 acres............................	19	"
e.	Over 640 acres	3	"

3. Duration of Study

a.	Duration not given	2	studies
b.	Three years or less	13	"
c.	Six years or less	28	"
d.	Ten years or less	38	"
e.	Ten years or more	9	"

4. Vegetation measurements taken (Yield, Utilization, Composition, Condition)

a.	Measurements not made	15	studies
b.	Measurements for one factor	15	"
c.	Measurements for two factors	15	"
d.	Measurements for three factors	2	"
e.	Measurements for all four factors	1	"

5. Soil measurements taken - None of the 49 studies made any mention of soil measurements.

6. Measurement of Animal Response - 18 studies apparently made no measurement of animal response to the treatment.

7. Description of the Vegetation - The dominant grass species was not mentioned in 17 of the studies.

8. Description of the Climate - No mention was made of precipitation in 26 of the studies.

9. Description of the Soils - 46 of the papers made no mention of soils.

In 1951, McIlvain and Savage wrote that "Many of the studies lack replication and proper controls, and some confound rotation grazing with other factors, such as rate of stocking, breed or species of stock, or fertilization." Twenty-two of the studies mention one of the following items and three others give indication of having one of the problems:

1. Ran out of feed and opened gates to all the pastures.

2. Fed supplemental feed to stock to prevent loss of weight.

3. Made changes in age and class of livestock used.

4. Attributed changes in vegetation to climate rather than treatment but failed to substantiate this with measurements.

5. Overgrazed all segments of the study which necessitated changes in stocking rates.

6. Made conclusions concerning certain items for which no measurements were made.

7. Made changes in grazing periods during study.

8. Lacked homogeneity in conditions of study.

As was previously stated, the practical range manager is interested in the effect of all variables of the grazing business, such as responses of soils, vegetation, animals, and the economics of the practice. Evaluation of the 49 studies was primarily from the standpoint of:

1. Milk production	3	studies
2. Livestock gains	27	"
3. Pasture improvement	13	"
4. Pasture improvement and livestock gains	2	"
5. Livestock gains and pasture improvement	1	"
6. Net returns and pasture improvement	1	"
7. Net returns and livestock gains............	1	"
8. Net returns	1	"

Conclusions

"The maximum number of cattle that can safely be carried on any square mile of territory is the number that the land will support during a poor season. Whenever this rule is ignored there is bound to be loss." (Smith, 1895). This "rule" is of the utmost importance in grazing management. It should precede or coincide with the initiation of any grazing management system.

A review of some research conducted on grazing management systems indicates that:

1. The two pasture rotation ("alternate") ("South African Switchback") system of grazing offers little or no benefit from the standpoint of livestock gains or range improvement. Most authors doubt that the system is economically justifiable.

2. The three pasture rotation offers a slight disadvantage to livestock gains and some advantage to increased pasture yields and improved pasture condition. Opinions appear to be divided on the economic feasibility of this system.

3. Rotations of 4 pastures or more - available literature was insufficient to support definite statements concerning this system. This system was studied with dairy cattle in a 6 pasture rotation and showed increases in livestock gains, milk production and grazing capacity. A four pasture study with cows and calves indicated that less utilization could be obtained with the same numbers under rotation.

4. Deferred rotation and rotational deferment - again there were too few research papers to support conclusions. Those reviewed showed an advantage in livestock gains. However, in recent years there have been numerous large-scale evaluation studies which indicate that livestock gains, pasture improvement in both vegetation and soils, and net returns are all benefited by these systems.

5. Rest-rotation - all authors appear to agree that this is the best long-range grazing system from all aspects of the livestock industry. This method appears to offer the greatest net returns per dollar of investment.

6. Deferred grazing - both research and evaluation studies of this practice are common. The key to range improvement apparently lies in the amount of rest provided the vegetation by deferment of grazing use during the growing season. Rate of improvement appears to be related to frequency and duration of rest. The fastest way to improve deteriorated range having sufficient cover for natural reseeding is through complete growing season deferment.

There is no grazing management system that is entirely satisfactory on an overgrazed range - First adjust the stocking rate; then apply management for range rest. The adjustment and amount of rest depend upon the desired and attainable rate and degree of range improvement.

HISTORICAL OR BACKGROUND PAPERS

Author	Date	Brief Description of Paper
Cole, et al	1927	Description of South Dakota and history of cattle industry.
Cotton	1905	Discussion of possibilities for deferred and rotation grazing on overgrazed ranges in Washington.
Jardine & Anderson	1919	Discussion of benefits of deferred and rotation grazing.
Sampson	1913	Description of life cycle of native plants and discussion of a 5 pasture rotation based on this study.
Sampson	1914	Description of life cycle of native plants in Oregon and the need for grazing management.
Sampson & Weyl	1918	Description of watershed erosion, some specific storms, and need for grazing management.
Sampson & Malmsten	1926	Range readiness and overstocking under a grazing management system.
Smith	1895	Description of plains regions and plan for subdivision and rotational grazing.
Smith	1899	Description of natural rest-rotation grazing by wild horses and buffalo. Range deterioration and need for deferred rotation.
Stoddart	1945	Discussion of range overuse and development of range management.
Vass	1926	"Boom and Bust" of Wyoming cattle industry and need for controlled grazing.
Wilcox	1911	Historical sketch of the Public Domain.
Wilson, et al	1928	Changes and problems of the ranching business of the Northern Great Plains.
Wooton	1915	Factors affecting range management in New Mexico.
Wooton	1908	Description of the territory of New Mexico and problems of the cattle industry.

RESEARCH STUDIES

Two Pasture Rotation

Rotation Grazing. Orderly sequence of use when each subdivision is both grazed and deferred during the same grazing season or calendar year.[3]

Author	Date
Biswell & Foster	1947
Biswell	1951
Black, et al	1937
Black & Clark	1942
Cole, et al	1927
Dickson, et al	1948
Fisher & Marion	1951
Frischknecht, et al	1953
Hawson, et al	1931
Heady, et al	1947
Hein & Cook	1937
Herbel & Anderson	1959
McIlvain	1951
McIlvain & Savage	1951
Moore, et al	1946
Rogler	1951
Smoliak	1960
Williams & Post	1945

Three Pasture Rotation

Author	Date
Ahlgren, et al	1944
Clarke, et al	1943
Fisser, et al	1962
Hubbard	1951
Hyder & Sawyer	1951
McIlvain & Savage	1951
Merrill	1954
Mott, et al	1952
Rogler	1951
Thomas & Young	1954
Woodward, et al	1933

Four or More Pasture Rotation

Author	Date
Hodgson, et al	1931
Hodgson, et al	1934
Johnson	1965

[3] American Society of Range Management - Range Term Glossary Committee. 1964. A Glossary of Terms used in Range Management. 32 pp., processed.

Deferred Grazing

Deferred Grazing. Discontinuance of grazing by livestock on an area for a specified period of time during the growing season to promote plant reproduction, establishment of new plants, or restoration of vigor by old plants (A.S.R.M., 1964).

Author	Date
Aldous	1935
Anderson	1940
Canfield	1940
Craddock & Forsling	1938
Douglas	1915
Freeman	1964
Hickey & Garcia	1964
Laycock	1961
Paulsen & Ares	1962
Reynolds	1959

Rest-Rotation

Rest-Rotation Grazing. An intensive system of management whereby grazing is deferred on various parts of the range during succeeding years, allowing the deferred part complete rest for one year. Two or more units are required. Control by fencing is usually necessary on cattle range but may be obtained by herding on sheep ranges (A.S.R.M., 1964).

Author	Date
Hormay & Evanko	1958
Johnson	1965
Rader	1961
Ratliff & Rader	1962
Sampson	1913
Woolfolk	1960

Deferred Rotation

Deferred Rotation Grazing. Discontinuance of grazing on various parts of a range in succeeding years, allowing each part to rest successively during the growing season to permit seed production, establishment of seedlings, or restoration of plant vigor. Two, but usually three or more separate units are required. Control is usually insured by unit fencing, but may be obtained by camp unit herding. (A.S.R.M., 1964).

Author	Date
Sarvis	1923
Sarvis	1941
Shepperd	1933
Shepperd	1939

Rotational Deferment

Rotational Deferment. A grazing system in which one or more parts of the range are rested during the growing season each year, and rotational use of other segments of the range are not necessarily planned for (A.S.R.M., 1964).

Author	Date
Freeman[4]	1961

[4]See evaluation studies.

EVALUATION STUDIES

Author	Date	Brief Description of Article
Anonymous	1963	Four pasture rotation on an 8,800-acre allotment in Wyoming.
Bay	1964	Five pasture rotation on a 23,523-acre allotment in Colorado.
Bohning & Martin	1956	Eleven pasture deferred grazing system in Arizona.
Dillon	1958	Five pasture rotation on 840 acres in Washington.
Dillon & Wallenmeyer	1966	Deferment on 6,500 acres in Washington.
Forest Service	1962	Four year results of deferred-rotation and rest-rotation on 2 allotments in Wyoming.
Fox	1966	Development and management in North-Central Arizona.
Freeman	1964	Effect of 4 pasture rotation on utilization patterns on an allotment in Northeastern Colorado.
Freeman	1964	Four pasture rotational deferment of a 13,000-acre ranch in Arizona.
Leavell	1960	Effect of early spring deferment on a 60,000-acre unit in Southeastern Oregon.
Leithead	1960	Eleven years of rotation-deferred grazing on 8,450-acre range in Washington.
Ridings	1960	History and development of a 6,296-acre allotment in Colorado (Rotation on horseback).
Rodgers	1966	Effects of rotational-deferred grazing on problem summer ranges in the Nebraska sandhills.
Sylvester	1957	Deferment on a 2,240-acre ranch in the sandhills. of Nebraska.
Udy	1960	Stocking rate adjustments and early spring deferment on a 35,000-acre unit in Idaho.
Waldron	1960	Changes in an overgrazed cattle allotment in eastern Oregon after 20 years of rotation grazing.

PAPERS PERTINENT TO GRAZING MANAGEMENT

Author	Date	Brief Description of Paper
Aldous	1935	Seven years of experimental burning on bluestem pastures in Kansas.
Campbell	1961	Four years of repeated seasonal grazing of 3 reseeded grasses and alfalfa (Canada).
Cotton	1907	Early reseeding work in mountain meadows of Washington.
Douglas	1915	Three-year trial of growing season deferment vs. total exclusion and proposal of 3 to 5 pasture rotation.
Dyksterhuis	1949	Discussion of range rest and recovery.
Fransden	1950	Rotation-deferred grazing on 16,000 acres in Arizona.
Griffiths	1910	Discussion of litter, range recovery, and reseeding trials in Arizona.
Hafenrichter	1957	Some literature on rotation grazing of cultivated pastures.
Hamilton, et al	1945	Discussion of rotation grazing on irrigated pastures.
Hickey & Garcia	1964	Changes in utilization by class of cattle.
Hormay	1956	Discussion of selective grazing and control through frequency of grazing.
Hormay & Talbot	1961	Discussion of the effects of selective grazing.
Jardine	1912	Five-year study of herderless sheep management.
Jardine	1915	Some literature on range improvement.
McMillen & Williams	1944	Description of Southern High Plains and five-year study on grazing recommendations.
Martin	1966	Discussion of proper use and mesquite control on semi-desert range lands on Arizona.
Morris	1932	Discussion of benefits of deferred and rotation grazing on Colorado ranges.

Author	Date	Brief Description of Paper
Morris	1934	Discussion of benefits of deferred and rotation grazing.
Mott	?	Discussion of problems and wrong procedures which may accompany grazing studies.
Ratliff	1962	Preferential grazing continues under rest-rotation grazing.
Reed & Peterson	1961	Stocking rates and grazing recommendations for Northern Great Plains.
Sheppard	1933	Cultivated pastures as aid to early spring grazing.
Springfield	1963	Sheep behavior as affected by small pastures.
Talbot	1961	Effects of 40 years of continuous use and need for a grazing management system.
Woodward, et al	1938	Description and study of the Hohenstein grazing system.

INFORMATIVE PAPERS

Author	Date	Brief Description of Paper
Blaisdell	1966	Status of Range Management - Past failures and future possibilities.
Bureau of Land Management	1951	Statistics on runoff and erosion from over-grazed Federal rangelands.
Burnett	1966	Cooperative approach to range improvement.
Campbell, et al	1962	Discussion of 2 and 3 pasture seasonal-rotation in Canada.
Chapline	1919	Discussion of seasonal use of range for goat management.
Forsling	1927	Discussion of grazing use in relation to watershed protection.
Frandson	1950	Rotation-deferred grazing or 16,000 acres in Arizona.

Author	Date	Brief Description of Paper
Freeman	1959	Discussion of growth characteristics of bunchgrasses and possibilities for rotation-deferred grazing on yearlong ranges.
Griffiths	1901	Discussion of problems and range research needs in Arizona grasslands.
Keng & Merrill	1960	Discussion of practicality of subdividing Texas ranches for rotation grazing.
Lang & Barnes	1942	Two years of clipping short and mid-grasses; possibilities for deferment and rotation.
Morris	1934	Deferred-and-rotation system of grazing.
Pickford & Reid	1942	Discussion of grazing use on mountain meadows and need for rotation and deferment.
Rowland	1937	Discussion of a method of deferred grazing for South African veld.
Thornton	1960	Discussion of deferred-rotation for management of big game livestock.

ABSTRACTS AND EXCERPTS

(ALPHABETICAL BY AUTHOR)

Ahlgren, H. L., I. W. Rupel, G. Bohstedt, and E. J. Graul. 1944. Eight Years' Results on the Effectiveness of Fertilization and Management in Increasing the Production of Permanent Pastures. Jour. Am. Soc. Agron. 36(4):301-315.

These studies were initiated in 1934 and were designed specifically to obtain exact information relative to the effects of management and fertilization on the production of permanent pastures under actual grazing conditions. The soil used in this study was comparable in fertility with that used for cultivated crops on the University Hill Farms at Madison, Wisconsin.

Grazing was deferred until August 16 in 1935 to permit the grasses and legumes to become well established. All fields were cut for hay during the period July 6 to 19. The pastures were grazed thereafter in the manner and according to the procedure given below. Fields 1 and 2 were grazed continuously until the forage had been completely utilized. Fields 3 and 4 were grazed rotationally. Each of these fields was subdivided by cross-fencing into three 3-acre paddocks. The cattle grazed the subdivisions within each of these fields in succession. The frequency with which the cattle were moved from one paddock to another in the rotationally grazed fields was determined by the rate of growth of the forage and the length of time needed to graze most of the forage down to height of 2 to 3 inches. Grazing was not uniform in either the continuously or rotationally grazed fields although there was a tendency for a more uniform type of grazing and for more complete utilization of the forage in fields 3 and 4 which were rotationally grazed than in fields 1 and 2 which were continuously grazed. The pastures were mowed each year at the end of the first grazing period to permit a more uniform regrowth. The droppings were scattered by hand in late October the first year and thereafter with a chain harrow.

All of the experimental fields were reduced in size from 9 to 6 acres in the spring of 1940 to make better use of available livestock facilities. Fields 3 and 4 were each subdivided into three 2-acre paddocks at this time.

Dairy cows were used for grazing the fields in 1935, 1936, 1937 and 1940. Dairy heifers were used in 1938 and 1939 and a mixed herd of dairy heifers and cows grazed the fields in 1941. The cattle were allocated according to the estimated production of the fields and in such a manner that approximately the same length of time was required for the removal of the forage from each of the fields.

Whenever the forage in any one of the four fields had been adequately utilized, the cattle were removed to supplementary pastures where they remained until the experimental fields had recovered sufficiently so that grazing could be resumed. The initial grazing procedure was

duplicated insofar as possible each year. Supplementary feed was provided in varying amounts to the milking cows, although the average amount fed per cow was the same for each field. The actual amount fed each cow was determined by the milk production. Records were kept of all supplementary feed consumed by the livestock and necessary deductions were made in computing total digestible nutrients produced by the experimental fields.

During 1935, the yield and botanical and chemical composition of the forage produced in the four fields were determined by periodic sampling of permanently enclosed square rod areas. Three square rod areas were located in each field. This method of sampling was believed to be unreliable and was abandoned in favor of the technique described below.

Excepting in 1935, movable wire cages each 4x4x1½ feet in size were used to determine yields of dry matter of the experimental fields. Eighteen wire cages were distributed at random in fields 1 and 2 and six cages on each of the paddocks in fields 3 and 4. Forage was harvested beneath the cages in fields 3 and 4 in a manner to approximate the grazing at the end of each grazing period. The forage beneath one-third of the cages in fields 1 and 2 was harvested in a manner approximating the grazing whenever grazing has been completed in one of the paddocks in field 3. Cages were moved to new areas selected at random immediately following each harvest. Representative samples were taken of the forage harvested beneath each cage for moisture and dry matter determinations.

Rainfall was considerably below average in 1934, 1935, 1936, and 1939. Rainfall was considerably above average in 1938 and 1941, although the distribution was poor in both years. In general, climatic conditions were least favorable for growth of forage in 1934, 1936, and 1939, and most favorable for growth in 1938 and 1942. The spring and summer periods of 1936 were characterized by unusually severe heat and drought.

There is no indication that the type of rotational grazing practiced in field 3 was superior to continuous grazing under the conditions of the study.

The average annual acre yields in pounds of dry matter produced by fields 1 to 4, respectively, were 2431, 4049, 3778, and 4076. Field 2, which was continuously grazed and fertilized annually with calcium cyanamid produced an average of 66.6% more forage per acre than field 1 which was continuously grazed but not fertilized with calcium cyanamid. Field 3, which was rotationally grazed and fertilized annually with calcium cyanamid produced an average of 55.4% more forage per acre than field 1. The average acre yield of dry matter obtained from field 4, which was rotationally grazed and maintained in alfalfa and Kentucky bluegrass, was 67.7% greater than that of field 1.

There is no evidence that the grazing management which was accorded fields 1, 2, and 3 had any significant effect on the botanical composition. There is some indication, however, that plants of redtop, timothy, alsike clover, red clover, and white clover persisted in greater numbers in field 1 than in either field 2 or field 3.

The average number of grazing days obtained per acre from fields 1 to 4 respectively during the period 1935 to 1941, inclusive, were 81, 135, 142 and 126. Fields 2 and 3 provided an average of 66.7% and 75.3% more grazing days per acre respectively than field 1. The average number of grazing days obtained from field 4 was 55.6% greater than that of field 1. Fields 2 and 3 provided an average of 9.9% more grazing days per acre during the period 1935 to 1941, inclusive, than field 4.

The data indicate that field 1 was less productive than any of the other fields on the basis of all methods of evaluation used. There was no difference of practical importance in the production of field 2, which was continuously grazed and field 3, which was rotationally grazed. Field 3 provided a few more pasture days per acre than field 2 during 5 of the 7 years of the study. Field 3 provided an average of 7 pasture days per acre more than field 2 during the period 1935 to 1941, inclusive, and only 12 pounds more total digestible nutrients per acre during the same period.

The production of fields 2, 3, and 4 did not differ significantly when evaluated in terms of yield of dry matter per acre. The yields of dry matter obtained from field 4 were greater than those of fields 2 and 3 in 4 of the 8 years, and lower than those of fields 2 and 3 in 3 of the 8 years. Differences in results obtained in fields 2, 3, and 4 when based on dry matter determinations, on the one hand, and total digestible nutrients and grazing days, on the other, may be due in part to sampling error.

Aldous, A. E. 1935. Management of Kansas Permanent Pastures. Kansas Agriculture Exp. Sta. Bull. 272:1-44.

More than one-third of the total acreage of Kansas is in permanent pasture. At least 90 percent of this land is nontillable because of steep slopes, excessive amounts of sand, or the thin or rocky nature of the soil. This makes it valuable only for its natural vegetative growth which provides pasturage for livestock. The present productivity of these lands varies greatly, depending upon the precipitation, type of soil, the natural vegetative covering, and the grazing management.

The Bluestem region is the most important grazing area of the state. The pastures in this region, commonly known as the Flint Hill region, are in good condition. They are vegetated with bluestem grasses, which were the original vegetative cover. These grasses are the most nutritious, most palatable, and highest-yielding native forage species in Kansas.

In the eastern part of the state the pasture lands were originally vegetated with bluestem grasses but owing to overgrazing, especially on the smaller farm pastures, the original species have been replaced mostly by bluegrass, annual grasses, and weeds. Many of these pastures still have sufficient stunted bluestem plants to restore the original stand of forage plants by conservative grazing management.

In the central part of the state the original vegetative covering was a mixture of tall and short grasses. The tall grasses consisted mainly of little bluestem, big bluestem, sideoats grama, prairie Junegrass, and prairie dropseed. The short grasses consisted for the most part of grama and buffalograss. The tall grasses occupied the slopes and stream bottoms, while the short grasses grew on the uplands and the thinner, poorer soils. Little bluestem is still the dominant grass in the more broken sandstone pasture lands situated mainly in Saline and Ellsworth Counties and extending northeast into Ottawa and Cloud Counties. Buffalograss, however, is now the dominant pasture grass in central Kansas. It has replaced the tall grasses because of close grazing.

The sandhills and broken nontillable areas adjacent to the principal streams in the western third of the state were originally vegetated largely by little bluestem. The rest of this region comprising the smooth hard lands supported an even stand of short grass composed of buffalo and grama. The vegetation of the sandhills is still predominantly tall grass. The short grasses have largely replaced little bluestem in the broken, nonsandy land, wherever the vegetation has been closely grazed continuously.

Economic studies conducted in various parts of the United States have shown that the cost of production of livestock and livestock products is reduced to a minimum when good pastures are used as a principal source of feed.

Pastures are reduced in productivity mainly because of close grazing. This results in a gradual weakening of the plants, the amount depending upon the closeness of the grazing and weather conditions. All the carbohydrates (starch and sugars) are elaborated in the leaves of the plant while the water and mineral nutrients (calcium, phosphorus, potash, iron, etc.) are taken in through the roots. The continued close removal of the top growth reduces the food-making capacity of the plant. The leaves are essential to the growth and maintenance of the vegetation. The close cropping of the top growth also results in a proportionate decrease in the quantity of roots. The defoliation is most detrimental to plant growth at the beginning of the season. This is because the plant draws on stored food reserves to make its initial growth and this process continues until the foliage has developed sufficiently to supply its growing needs. Later in the season the food reserves used for starting growth are restored. Studies have shown that the food reserves of protected or lightly grazed bluestem grasses are not completely restored in an average year until about the middle of June. From this time until the close of the growing season the cropping of the foliage is less harmful than earlier.

Experiments in clipping vegetation have demonstrated that a very thrifty stand of bluestem grasses can be reduced two-thirds in density and three-fourths in annual yield by clipping to a height of 1 inch every two weeks for three successive years. This treatment is less severe than grazing the vegetation similarly close, because, in grazing, the animals pack the soil, which causes a reduction of aeration and bacterial action. This decreases nitrate development and limits growth, because available nitrogen is the principal limiting nutritive element in most of the Kansas grasslands.

Another factor entering into the reduced productivity of permanent pastures on this type of land is the decreased fertility. This is a major factor in humid regions, especially where the soil in its virgin condition is low in any one of the essential elements. The continued removal of the grass cover and the subsequent leaching and erosion of the soil reduces one or more of the nutrients essential to plant growth to such a low point that they become the limiting factors in the vegetative growth.

The abundance of weeds in many run-down pastures, especially in the eastern part of the state, makes the eradication of the worthless vegetation the first step in the logical improvement of this land. The desirable forage plants can be restored in a minimum length of time by removing the competition from the weeds or brush. This should be accompanied by grazing practices that permit the forage plants to make sufficient top growth to occupy the ground when the weeds are eradicated.

There are four direct methods that can be used to eradicate weeds and brush from pastures. They are as follows: (1) cutting, (2) grubbing, (3) burning, and (4) the use of herbicides.

Burning in the spring is quite generally practiced in eastern Kansas on bluestem pastures following seasons when growing conditions were favorable and growth of the forage was high. Since it is impossible to anticipate the yield of forage in the pastures, the stocking has to be based on their grazing capacity in an average year. As a result there will be a large amount of unused vegetation at the end of a favorable season. If this dead grass is allowed to remain throughout the next grazing season, it may result in uneven grazing. Places where the livestock prefer to graze, such as the stream bottoms, ridge tops, and near water, are heavily grazed while the steeper, more rocky slopes or areas farthest from water will be undergrazed. Pastures are burned in some instances to control weeds and brush and to stimulate earlier growth of forage in the spring.

To obtain information on these and other questions that frequently arise from the practice of burning pastures, experiments have been conducted during the past seven years on two types of bluestem pastures located near Manhattan. One area is a typical flint hill type of pasture land, in which a mixture of prairie grasses composed of 60 to 70 percent big and little bluestem is growing. The other area is level, tillable upland with 50 percent of its vegetative covering little bluestem. Other less common grasses include big bluestem, Indiangrass, prairie Junegrass, hairy grama, and Kentucky bluegrass. The experimental areas were burned in the late fall or about December 1, early spring or about March 20, medium spring approximately April 10, and late spring or between May 1 and 10. One set of experimental plots was burned yearly and another set in alternate years at the above specified dates.

Burning affected the pastures mainly by decreasing the yield of vegetation the succeeding year. Burning every year in the late fall decreased the yield about 65 percent; early spring burning, 50 percent; medium spring, 42 percent; and late spring, 14 percent. Where the burning was done in alternate years, the yields were 10 to 15 percent higher than from plots burned at the same time every year.

Burning in the early and medium spring had little effect on the succession or change in the species of vegetation with the exception of Kentucky bluegrass, which was eliminated from all the plots that were burned more than three years in succession. Burning in the late fall had a tendency to increase the little bluestem and decrease big bluestem and Indiangrass. Burning in the late spring caused an increase in big bluestem and Indiangrass and a corresponding decrease in little bluestem. When bluestem pastures were burned between March 20 and April 10, which is the usual time to burn in the vicinity of Manhattan,

little change was recorded in the vegetation. Out-of-season burning, such as early winter, which is sometimes practiced in bluestem pastures adjacent to farm land to remove cover for chinch bugs, and late spring burning which is done to control certain weeds and brush, will cause a change in the composition of the vegetation as indicated above if continued yearly for more than three years in succession.

The experiments have shown that burning stimulates early growth in the spring. This was caused mainly by an increase in soil temperatures. Where sufficient soil moisture is available to promote plant growth, the increased temperature caused as a result of burning was sufficient to increase materially the amount of vegetation. This increase is greatest where growth starts early in April, and gets progressively less as the season advances. The growth of the vegetation by April 10 on the early spring burned area averaged approximately 35 percent greater than on the unburned. When livestock were turned into the pasture about May 1, the amount of vegetation on the burned area was approximately 25 percent more than on the unburned areas. By June 15 there was little if any difference in the amount of vegetation on the two areas because at this time soil moisture rather than soil temperature was the limiting factor in plant growth. The difference in yield was most pronounced in cold wet seasons and least in warm dry ones.

Contrary to popular belief, burning did not cause any decrease in the total nitrogen or in the organic content of the soil. This may be attributed to the fact that the maintenance of the organic and total nitrogen content of the soil is due more to root development than to accumulations from the top growth. The root growth, however, is directly proportional to the amount of top growth. The data available indicate that the roots of grasses are relatively short lived and are replaced to a large extent every two or three years. This would amount to about 2 tons of root material per acre on pasture land containing a good stand of bluestem grasses. The amount will vary from 1,000 pounds on poor pasture land to as much as 7,000 pounds on a good stand of bluestem grasses that has been moderately grazed.

Burning pastures is not effective for controlling weeds and brush unless it is done in the late spring, after April 20. To be effective the burning should not be done until after the plants which are to be eradicated have made 3 inches or more of top growth. The nearer the time of burning corresponds to the time of the lowest point in the food reserves the more effective it will be. Burning can be used effectively to eradicate buckbrush, as this shrub starts growth early in April and is fully in leaf by May 1. The main problem in eradicating buckbrush by burning is to have enough inflammable material to carry the fire over the ground. This may be accomplished by protection or by light grazing during the season previous to burning. Where the stand of brush is so heavy that the growth of the grass is excluded because of shading, straw or other inflammable material can be scattered rather lightly over the ground to carry the fire.

Sumac cannot be eradicated effectively by burning because it usually does not start growth until after May 1. Experiments have shown that burning is not harmful to sumac unless it is done the latter part of May. The grasses and other species of herbacious vegetation have made enough growth by this time to make burning almost impossible unless the season is abnormally dry, in which event it probably would not be advisable to burn.

Nearly all the weeds starting growth early in the growing season can be controlled effectively by late spring burning. At the close of the growing season the average weed content of the plots burned in the late spring was about 2 percent on one area and about 1.5 percent on the other. The vegetation on the plots burned in late fall, early, and medium spring contained from 13 to 19 percent weeds on one area and 4 to 6 percent on the other. All the plots burned at these three periods had a greater weed content than the unburned area.

Information is frequently requested on the correct time for burning pasture. Burning for the purpose of removing the dead grass to stimulate uniform grazing should be done some time between March 20 and April 15 in the vicinity of Manhattan. These dates should be advanced about one week in the southeastern part of the state. Pastures should be burned just before the big and little bluestem grasses start growth, and if possible when the ground is wet. The latter is of much greater importance than the time of burning. In all the experiments mentioned above the burning was done when the ground was wet. Perhaps if the burning had been done when the ground was dry different results would have been obtained, particularly on the succession and density of the vegetation on the burned plots and the total nitrogen and organic content of the soil.

The aim in the management of pastures should be to obtain the greatest possible production of livestock without decreasing the productivity of the forage plants. To accomplish this necessitates the use of such grazing methods and rate of stocking as will permit the forage plants to make enough top growth to maintain their vigor. It is especially important in the management of pastures to avoid grazing too early in the spring as this is the most critical period in the life of most perennial pasture plants. Whenever possible livestock should not be turned into the permanent pasture until the vegetation has made sufficient top growth to permit the animals to obtain a mouthful readily.

Deferred grazing consists of postponing or delaying grazing in a pasture for a part of the growing season to permit the vegetation to make sufficient top growth to maintain its vigor.

This protective period for the bluestem grasses can be applied most effectively at the beginning of the growing season, because at that time the grasses draw on their root reserves to start growth. This

process continues until there is sufficient top growth to supply the growing needs of the plants.

Experiments conducted on a typical bluestem pasture near Manhattan, in cooperation with Mr. Dan Casement, have shown that the deferred system increased the grazing capacity approximately 35 percent. Livestock grazing the deferred pasture made a daily gain of 78 pounds per acre, while the pasture grazed season long made a daily gain of 65 pounds per acre. Cows and May calves were used in the experiment.

A deferred and rotation system of grazing is designed primarily for pastures which contain the type of forage that requires the occasional maturity of seed to maintain its normal density. This applies mainly to the regions of lighter rainfall where the forage plants are largely replaced by seed rather than vegetatively by stolons or roots.

Pasture plants, particularly perennial grasses, are the most effective type of vegetative growth for checking erosion throughout a major part of Kansas. This is because their fibrous roots thoroughly penetrate the soil, binding it against erosion. Grass roots often extend to a depth of 8 feet in some of the deeper soils in the eastern part of the state. Grasses also prevent erosion because they prevent the accumulation of run-off into rivulets and because the individual stems serve as dams, thereby reducing the rate of flow. The extensive fibrous root system of grasses increases the absorptive capacity of the soil.

The amount of run-off and erosion from pasture land will be governed to a large extent by the composition and density of the vegetative cover. This in turn will be controlled mainly by the intensity of grazing.

Anderson, Kling L. 1940. Deferred Grazing of Bluestem Pastures. Kansas Agricultural Experiment Station. Bulletin #291, 27 pages, illustrated.

That part of Kansas known as the Flint Hills or bluestem pasture region occupies about five million acres. The original cover of native bluestem grasses still remains and is used for grazing on most of this area. A large portion of the land east of the Flint Hills is now cultivated, but there still remain in that section small acres that have never been cropped. Many of these areas are used as hay land and others are pastured.

In the Flint Hills most of the pastures are grazed by transient cattle from the ranges of the Southwest. These cattle are brought to pasture about May 1, or as soon as the bluestem grasses begin their spring growth, and are shipped out of the region as soon as they have made sufficient gains or have attained sufficient finish for marketing. Shipping begins as early as July and continues during the summer and early fall so that by September almost all of the transient cattle have been removed.

East of the Flint Hills most of the pastures are grazed by farm herds of dairy or beef cattle. These pastures usually are smaller, and are often more severely overgrazed than those in the Flint Hills. The bluestem grasses, the most desirable of the forage species, are grazed first and as a consequence are depleted almost to the point of complete elimination in some pastures. Brush, weeds, and weedy grasses have taken their place so that now these pastures are greatly reduced in productivity.

The bluestem pastures have steadily decreased in carrying capacity since they were first used extensively for grazing. Old grazing records show that prior to 1900 most of the bluestem pastures could be stocked at the rate of two acres for one mature cow or steer for a grazing season of six months beginning May 1. By 1933, or just before the recent years of drought, the best pastures could carry only one mature animal on four acres, while the average carrying capacity was five acres per animal. At the present time the average grazing capacity is about seven acres per animal.

Experiments were started about 25 years ago by the Kansas Agricultural Experiment Station in cooperation with Dan D. Casement, a cattleman at Manhattan, Kansas, to obtain information on methods of grazing which would improve the productivity of native bluestem pastures. These experiments were planned and established in 1915 on typical bluestem pastures 10 miles north of Manhattan and detailed information was first recorded in 1916. Prior to 1913 these pastures had carried beef

cattle at the rate of three acres per animal unit with no apparent damage to the grass. In 1914 four acres were allowed for each animal unit, but at the end of the grazing season the pasture seemed injured so that in 1915 five acres were allowed.

The early experiments were designed to study the effect of deferred and rotation grazing on the productivity and maintenance of stands of the bluestem grasses. Grazing was delayed until about September 1 each year on the deferred portion of the pasture. By that time the tall grasses had reached a fairly advanced state of maturity and had become greatly reduced both in palatability and in nutritive value. As a consequence it was not possible to obtain uniform or maximum utilization and about one-half of the vegetative cover remained at the end of the grazing season. In 1920, the date of deferred grazing was changed to June 15, allowing for some spring protection and also permitting the grass to be utilized while still leafy and palatable. By June 15, the grass usually had made sufficient growth to maintain its vigor under conditions of fairly close grazing.

Pasture unit A is deferred the first year, B the second, and C the third, according to this plan. While one unit is being deferred, the cattle are placed on the other two units. By July 1 the grass on the deferred unit will have made considerable top growth; and in order to utilize this efficiently it will have to be grazed rather quickly, so all of the cattle from the other two units are placed upon it. Later in the season, if the grass becomes closely grazed in the deferred pasture, the gates may be thrown open and all three units grazed as one.

This system of grazing is especially applicable to pastures in private ownership and grazed by local cattle. Pastures grazed by transient cattle from the Southwest present a somewhat different problem. Leases usually demand that they remain on the same pasture throughout the grazing season, and until this can be changed, deferred grazing will have little place on the so-called commercial pastures.

Experiments were started in 1916 to compare deferred and rotation grazing of the bluestem grasses with season-long grazing.

When grazing was deferred until September 1 the carrying capacity was not increased because it was not possible to obtain maximum or uniform utilization. However, when the beginning of the deferred grazing period was changed to June 15, there was a decided increase in carrying capacity.

The original set of experiments was discontinued in 1922, but since 1927 grazing deferred until July 1 has been compared to season-long grazing.

The deferred pasture has had a higher carrying capacity than those grazed season-long either in terms of time actually grazed or when converted to a six-months grazing season.

Gains of livestock have been greater on the deferred pasture than on the pastures grazed season-long. The deferred pasture has yielded an average of 65.1 pounds of beef per acre per grazing season compared to 37.4 pounds and 42.5 pounds for the two season-long pastures.

Gains per animal unit per grazing day have also been higher on the deferred pasture. Cattle on this pasture have gained an average of 1.32 pounds per animal unit per grazing day as compared to 1.17 pounds and 1.09 for the pastures grazed season-long.

Seasonal gains per animal unit have been somewhat smaller on the deferred pasture. However, it has required about twice the acreage on pastures grazed season-long to produce about one-third more gain per animal unit per grazing season. Furthermore, it has taken from 40 to 50 days longer each year to do this.

As a result of spring protection, stands of grass on the deferred pasture have been maintained in better condition in spite of the fact that it has been subjected to much harder use. At the end of each grazing season it had a better cover of grass to afford protection against runoff and erosion during winter and spring.

Severe climatic conditions during the last several years of this experiment caused severe depletion of the grass population. Later when the depleted grasses were replaced, a great deal of sand dropseed and buffalograss appeared on the pastures grazed season-long, whereas in the deferred pasture sideoats grama was largely responsible for this replacement.

To permit deferred grazing, it is thought advisable to provide other forms of pasture during May and early June. For pastures where the stand and vigor of the vegetation are good, a plan of a deferred system of grazing is suggested in which supplemental pastures are not needed.

Bay, Ovid. 1964. What it Takes to Bring Back Range. Reprinted from the April 1964 issue of Farm Journal.

Donald Baldwin swung down from the saddle and watched his cattle head up a draw lined with aspen trees last June 10.

"We're turning 10% more cattle into the Forest today than we did last year," he told me. "It's an across-the-board increase -- good for the next five years. If the range holds up under the increased grazing, this 10% will become permanent and we might even get another boost."

Just how do you improve public range so allotments hold or go up? In this instance, the ranchers elected a committee to meet with the rangers and talk over what needed to be done. They settled on three main efforts.

1. Put in more watering spots. Cattle were passing up some of the best grass because it was too far from good water. Five miles, in fact.

With the ranchers contributing both labor and cash, they dammed up draws and scooped out seeps and springs, then fenced them off to keep the cattle from tramping them dry. All told, they've put in more than 90 new watering spots during the last 10 years.

2. New grazing systems. So grazing could be controlled, they began putting in fences. Today, 35.5 miles of fence - most of it four-strand - divide 23,523 acres of usable range into five cow-calf pastures and five yearling pastures.

They're using various grazing systems, including rest-rotation. Under such a system, the five pastures are grazed in sequence. In turn, and over five years' time, each pasture gets a rest for a full season. The other four are rotation-grazed in early, medium, and late season.

The exact time-table depends, of course, on moisture, the over-all condition of the range and the amount of growth in each pasture. Other systems, such as simple rotation, deferred rotation or other combinations are sometimes used.

So far, no reseeding has been done. "Most of the native grasses we want are thickening up by themselves," says Baldwin.

3. Spraying for weeds and brush. "Biggest surprise to me has been how quickly the grass improves after it is sprayed with 2,4-D," says Clifford Schulze, secretary-treasurer of the Beaver Creek Cattle Assn.

They use sprayed pastures for the last rotation of the next season to give them a chance to recover and reseed, Baldwin says.

Several ranchers now report that they're getting 15 to 20 lbs. more gain per yearling each season.

"With heavier cattle to sell and a 10% increase in the number of cow-calf pairs we can turn out, we're getting back every dime we spend and then some," says David Rawhouser, Jr., another rancher in Weston County, Wyoming. "Just knowing that the range is getting better is worth a lot, too."

But it costs. Since 1956, the ranchers have kicked in 35¢ per acre, plus labor. The Forest Service has spent $1.33 per acre, plus labor of its employees. Biggest expense has been fencing.

Biswell, H. H., and J. E. Foster. 1947. Is Rotation Grazing on Native Pastures Practical? North Carolina Agric. Expt. Sta. Bull. 360, 17 pages, illus.

At the Blackland Branch Station two rotational systems were tested by comparing each with continuous grazing. The systems and range layout were as follows:

(1) Continuous grazing, check groups. The animals were divided into two uniform subgroups. These were grazed on areas 1-a and 1-b (Fig. 1) continuous but they exchanged areas every 28 days. By this system, of course, the areas were stocked with only half as many animals at any particular time as were the areas under rotational grazing.

(2) Mid-season rotation. The animals under this system were grazed in areas 2-a each year until August, at which time they were moved to areas 2-b where they remained until the end of the grazing season.

Therefore, under this system each area was used about half of each grazing season and rested the other half.

(3) 28-day rotation. The animals here were grazed in areas 3-a and 3-b, but each group was moved from one area to the other every 28 days throughout the grazing season. By this system each area was grazed 28 days and then rested 28 days.

Heifer Ranges

3-b	1-b	2-b	3-a	1-a	2-a
28-day rotation	Continuous grazing	Mid-season rotation	28-day rotation	Continuous grazing	Mid-season rotation

2-b	3-b	1-b	2-a	3-a	1-a
Mid-season rotation	28-day rotation	Continuous grazing	Mid-season rotation	28-day rotation	Continuous grazing

Steer Ranges

to scales

The range pastures were 15 acres each in size and were stocked so that forage was always sufficient and degree of utilization was moderate. Previous to starting the studies the areas contained practically a uniform cover of reeds seven to nine feet tall. Soon after the areas were fenced, however, a severe wild fire during a dry period in the fall of 1941 burned the muck soil in spots to a depth of 12 to 16 inches.

These studies indicated that the three systems of grazing gave about the same results under moderate utilization. No appreciable differences occurred in forage density, species composition, or utilization due to the grazing systems. Furthermore, the cattle gains were essentially the same under all three systems of management.

Throughout the experiment, the density of the vegetation remained uniform among the different treatments, indicating that the grazing systems had no appreciable effect on the forage cover. Furthermore, the grazing systems produced no appreciable changes in the amount of each species.

No significant differences in cattle weight gain showed up under the three systems of grazing management.

Although the gains in weight were not significantly different, the cattle under continuous grazing gained slightly more on the average than those under the 28-day rotation system and the cattle in each of these gained a little more than those under the mid-season system.

Biswell, H. H. 1951. Studies of Rotation Grazing in the Southeast. Jour. Range Mgt. 4(1):53-55, illus.

Studies of rotation grazing in switch cane (Arundinaria tecta) areas in eastern North Carolina were made over a three-year period to determine: (1) if a rest from grazing is beneficial to the forage plants in allowing them a period of undisturbed growth even though they must support more animals during the time they are grazed, and (2) to find effects on cattle gains.

The forage was studied as to vegetation density, species composition, and utilization; the cattle were weighed every 28 days and grazing habits observed. The pastures were stocked so that forage for the cattle was always sufficient and the areas were moderately grazed.

Two rotation systems were tested by comparing each with continuous grazing:

1. Mid-season rotation grazing. Each pasture was used about one-half of each grazing season, from May to November, and rested the other one-half.

2. Twenty-eight day rotation grazing. The animals were shifted between pastures every 28 days.

3. Continuous grazing for control or check. Grazed with 1/2 as many at any one time as other pastures. Animals exchanged between areas every 28 days to simulate changes in other groups.

The experiment was replicated once with steers used in one set of pastures and heifers in the other. Results showed no significant difference in gains of the steers and heifers.

No appreciable differences occurred in forage density, species composition, or utilization as a result of the grazing systems.

No significant differences in cattle weight gains showed up under the three systems, although the cattle under continuous grazing gained slightly more on the average than those under the 28-day rotation. And the cattle in each of these systems gained more than those under the mid-season system. Cattle weight gains for the three years averaged as follows: continuous grazing, 147 pounds; 28-day rotation grazing, 145 pounds; and mid-season grazing, 138 pounds.

There seems to be no advantage in rotation grazing in switch cane forage where the rotation plan requires a doubling up of grazing pressure during the time a range is used.

Other studies in switch cane forage indicate that conservative grazing is important in maintaining vigor of the plants and grazing capacity; therefore, emphasis in management could well be placed on conservative use rather than on rotation grazing.

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Black, W. H., A. L. Baker, V. I. Clark, and D. R. Mathews. 1937. Effect of Different Methods of Grazing on Native Vegetation and Gains of Steers in Northern Great Plains. USDA Technical Bull. 547, 19 pages, illus.

The problem of handling native pastures and ranges in a manner to obtain the greatest returns from them without injury to the vegetation has become of considerable importance in the northern Great Plains. This region includes eastern Montana, eastern Wyoming, western North Dakota, western South Dakota, and northwestern Nebraska.

The native vegetation of the northern Great Plains is made up of a large number of species from widely separated families. It is dominated in the vicinity of Ardmore, S.Dak., by western wheatgrass (*Agropyron smithii*), buffalograss (*Bulbilis dactyloides*), and blue grama grass (*Bouteloua gracilis*).

The native vegetation of this region as a whole has two seasonal aspects. In the spring the early grasses, such as plains bluegrass and prairie Junegrass, are very noticeable. Later in the season, western wheatgrass and some of the legumes are more in evidence. As already stated, buffalograss and grama generally form most of the basal cover throughout the season. In comparison with cultivated grasses, native grasses as a whole are slow in making enough growth to provide pasture in the spring.

Three pastures were used in these experiments. Two of these pastures, one 80 acres and the other 150 acres in size, were grazed continuously each year. Until 1931 equal numbers of steers, from 10 to 15 each year, were kept on each of the two pastures. The 80-acre pasture was designed to be overgrazed, and the 150-acre pasture was expected to furnish ample feed during the grazing season. These expectations were not always fulfilled. In a few good years the 80-acre pasture was not overgrazed; and in exceedingly dry years the 150-acre pasture did not furnish ample feed.

For several years previous to 1931, owing to shortage of feed on the 80-acre pasture, it had been necessary to remove the steers from this pasture before the end of the grazing season on the other pastures. Consequently, in 1931 the number of animals on the 80-acre pasture was reduced to eight in the hope that the grazing season would be prolonged to near the end of September.

In 1931, also, the use of the 150-acre pasture was discontinued and part of it was made into an 80-acre pasture in which cracked barley was fed as a supplement to pasture.

A third experimental pasture, 160 acres in size, was divided into two equal sections that were grazed alternately, one from the beginning of

each year's experiment (about May 21) until about August 1 and the other from then until the close of the experiment (Oct. 18 or earlier). One section was grazed the fore part of the season for two consecutive seasons and during the latter part of the season for two consecutive seasons. This method was designed to permit grasses to mature and the seedlings to become established.

Changes in vegetation in the isolation transects were not so marked as those reported from pasture investigations in other regions. This was probably due to the fact that the most abundant grasses in the pastures at Ardmore are not permanently injured by close grazing.

No difference was found in the appearance of the vegetation in the different transects, indicating that the grazing in the 80-acre pasture was not severe enough to cause material changes in the vegetative cover. On this pasture the four important grasses were as abundant in 1930 as they were at the beginning of the experiments, and there was no increase in unpalatable species. No species showed signs of having benefitted from the close pasturing.

Alternate grazing, as practiced on the 160-acre pasture, did not affect materially the character or quantity of the vegetation. The unusually good opportunity for reseeding on one-half of this pasture each year apparently was of no importance as, on all pastures, the four important grasses in this section spread readily.

The vegetation of the 150-acre pasture did not change noticeably during the experiments. No decrease in the palatable species or increase in the less palatable species was observable. Grazing was close enough so that there was no accumulation of old vegetation.

The 150- and 80-acre continuously grazed pastures were comparable throughout the experiments, since the latter pasture was grazed nearly twice as intensively as the former during each year from 1919 to 1930. The average gains per head in May and June were substantially the same. So long as feed was abundant, the intensity of grazing had little effect on the gain.

The average gain per head on the 80-acre pasture for the entire investigation was materially lower than on the 150-acre pasture. However, in terms of gains per acre, the 80-acre pasture was 38 percent higher than the 150-acre pasture during the entire investigation.

The total average gains per head and average gains per acre from 1919 to 1924 were slightly higher for the steers on the 160-acre pasture alternately grazed, than for those on the 80-acre pasture continuously grazed. However, since there were no significant differences between the gains of these two pastures it was considered desirable to lower the rate of stocking on the 160-acre pasture, and accordingly it was

stocked to provide 10 acres per steer, two-thirds as many as in the 150-acre pasture. As a result, for the second 6-year period, 1925-30, the average gain per acre was again slightly in favor of the alternately grazed pasture, whereas the gain per head was one-third greater for the alternately grazed pasture than for the continuously grazed 80-acre pasture.

When steers are being grazed for feeder production there is an advantage in the heavier rate of stocking. On the other hand, when the production of grass-fat slaughter cattle is desired, the increased gains on the steers, resulting when the animals have been kept on a lightly stocked pasture, are likely to enhance their market value materially. When the selling price of the steers is the same, the pasture producing the greatest gain per acre is the most profitable. If the greater gain per head on a pasture enables the steers to reach a condition commanding a higher selling price, the price difference may more than make up for the difference in gain per acre.

Vegetation of the type making up the pastures at Ardmore is not likely to be damaged if it is not grazed so closely that the animals grazing it suffer severe loss in weight. Accordingly, the effect on the steers and not the effect on the vegetation is the limiting factor in determining how heavily such a pasture should be stocked.

In the last 3 years of the investigation, steers on pastures alternately grazed made significantly greater gains than steers grazed on pasture continuously at the same rate of stocking. The gains per acre were likewise significantly greater in alternate grazing. This method of grazing, therefore, was more efficient than continuous grazing. The gain per acre exceeded that on the other pastures with which no supplement was used. The gain per head was greater than on the 80-acre pasture without supplement but less than on the 150-acre pasture and the 80-acre pasture with barley supplement.

Black, W. H., and V. I. Clark. 1942. Yearlong Grazing of Steers in the Northern Great Plains. USDA, Circ. 642, 16 pages, illus.

Experiments were carried on at the Ardmore Field Station, Ardmore, South Dakota, for 4 successive years, beginning in the fall of 1936, to determine whether about 20 acres of native range were sufficient to carry a yearling steer for 1 year and whether alternate grazing would have any advantage over continuous grazing. Two areas of 350 acres each were used, one of which was grazed continuously and the other divided into two equal areas of 175 acres each and the steers changed from one half to the other every 28 days. The rate of stocking was 19.44 acres per head, or 18 animals for each of the 350-acre tracts. The animals used were yearlings, approximately 16 months of age at the beginning of each experiment and were grazed for 1 full year.

The vegetation was the native range, which includes a large number of species from widely separated families. The vegetation is dominated, however, by western wheatgrass (Agropyron smithii) buffalograss (Buchloe dactyloides) and blue grama grass (Bouteloua gracilis). During the period covered by the study, precipitation was favorable for vegetative growth.

Low precipitation and extreme temperatures, which are common to the greater part of the area, make crop production rather uncertain.

The experiments were begun in the fall of 1936 and continued for 4 successive years. Each year 36 head of range-bred Hereford yearlings of good to choice quality were used. Steers only were used in all experiments except the fourth, when there was a shortage of these animals. In this experiment spayed heifers, as well as steers, were included. To allow the heifers time to recuperate from the spaying operation, the fourth experiment was begun about 5 weeks later than the preceding ones.

By random selection the cattle were divided into 2 groups of 18 each. After this division usually one or two shifts were made. One group was placed on pastures having a total area of approximately 350 acres, to graze continuously for 1 year. The other group was grazed on pastures of equal total area but subdivided into 2 equal areas of 175 acres each, which were grazed alternately every 28 days. The native range at the Ardmore Field Station and vicinity consists of many species from widely separated families, but western wheatgrass (Agropyron smithii Rydb.), buffalograss (Buchloe dactyloides (Nutt.) Engelm.), and blue grama (Bouteloua gracilis (H.B.K.) Lag.) predominate.

1936-37

As both groups of steers lost considerably in weight from the latter part of October to the first part of February, the range was supplemented

intermittently from December 4 to April 7 with small quantities of cottonseed cake, alfalfa hay, and oat straw. Both groups of steers lost about the same weight during the winter months. The continuously grazed group averaged 23 pounds greater total gain per head during the spring and summer grazing season than the group grazed alternately. For the entire experiment the difference in average gain, although in favor of the continuously grazed group, was not significant.

Both groups of steers produced carcasses grading about average good. The difference in carcass grade was not significant but was slightly in favor of the continuously grazed group.

Observations of the condition of the two pastures showed a slight difference, at the end of the experiment, in favor of the one alternately grazed. However, in this experiment as well as the later ones, neither pasture had the appearance of being overgrazed.

1937-38

During the spring and summer grazing period the alternately grazed group gained more than the one kept on the same range continuously. For the entire period of 364 days the alternately grazed group gained 26 pounds per steer more than the other group.

The steers did not have sufficient finish to be attractive as slaughter animals. Both groups sold at the same price per hundredweight, but the alternately grazed group graded slightly higher than the continuously grazed group at the conclusion of the experiment.

1938-39

The yearly steer gains for each group in the 1938-39 experiment were similar to those made by the corresponding groups in the 1937-38 test. The steers in each group finished the test at essentially the same weight, there being only 3 pounds difference in favor of the steers using the alternately grazed range. The steers did not carry sufficient finish to be in demand as slaughter cattle and hence were sold as heavy feeders, both groups selling at the same price per pound.

At the end of the experiment, the continuously grazed pasture was observed to have an appreciably better stand of vegetation than the one alternately grazed. This result is contrary to those obtained during the previous two years.

1939-40

During the 140-day spring and summer period, the group on the alternately grazed area gained 26 pounds more per head than the group on the continuously grazed area. During the entire period of 364 days, the group on the continuously grazed area gained 14 pounds per head more than the

other group. This difference, however, was not significant. Both groups sold as feeders at essentially the same price per hundredweight.

At the end of the experiment, there was no difference in the observed appearance of the continuously grazed and alternately grazed pastures. Furthermore, after 4 consecutive years of use, these pastures showed no ill effects of the rate of stocking employed.

Blaisdell, James P. 1966. Range Management Viewed from Fore and Aft on a Fabrication of Facts, Figments, and Filosophy. Abstracts of papers presented at the 19th Annual Meeting, ASRM, pp. 35-37.

This paper is based on the assumption that it is worthwhile in most any endeavor to pause occasionally and examine the status quo. It appraises the present situation in both range management and research, takes a critical look at the past, and suggests some possibilities for the future. The individual ideas included are not particularly new or revolutionary, but an attempt is made to weave facts, theories, and philosophy into a compact, interesting fabric.

Listing his gray thatch as his principal qualification, the author arrives at the following conclusions:

1. Although much progress has been made in management of both public and private rangelands, there is no place for complacency. Many ranges are in unsatisfactory condition and deterioration is continuing.

2. Actual grazing is necessary to determine grazing capacity, and precise determination by other means should not be attempted.

3. Overoptimism concerning the grazing capacity of rangelands has been an important factor in their deterioration.

4. Preoccupation with exact measurement of herbage utilization seems to have retarded progress.

5. Much effort has been misplaced in attempting to develop refined grazing systems, in view of the difficulties in actually applying them to large, variable range units.

6. Failure to give enough emphasis to soil and site characteristics has detracted from success in range management.

7. Insufficient consideration of people as important parts of the range ecosystem has certainly retarded progress.

8. Attempts to make range management an exact science has also hindered application of sound management.

9. Range ecology studies have provided much usable information, but many factors of the community have been neglected.

10. Although success in direct range improvement research has perhaps been more apparent than real, empirical seeding and plant control studies have provided the basis for rehabilitating millions of acres of deteriorated rangelands.

11. Grazing experiments have provided much usable information on effects of various management practices, but they have been expensive and have often failed to meet specific objectives.

12. Range management is an art that requires fundamental information about the range ecosystem, particularly characteristics and requirements of the vegetation and how it reacts to grazing use.

13. Since good management practices can be highly variable, flexibility should be allowed and even encouraged.

14. Range management practices have been largely developed from empirical studies and are supported by a rather narrow base of fundamental information. Basic research to broaden this base should attempt to develop laws or principles - not merely isolated facts.

15. The most critical need in range management is for reliable indicators of trend in range condition; consequently, fundamentals of vegetal change must be emphasized.

16. Deliberate manipulation of vegetation through rather drastic treatments is suggested as a means of accelerating progress in appraising change.

17. Increased emphasis is needed on classification and evaluation of range sites and on how to measure vegetal attributes.

18. Synecological studies should be extended to more range communities and broadened to include consideration of more factors.

19. Emphasis on autecology and physiology is needed for solution of range seeding problems and for determination of plant tolerances to such factors as fire, chemicals, and herbage removal.

20. Grazing experiments should be concerned primarily with range community dynamics (synecology) and only secondarily with development of precise grazing systems for practical application.

21. Stereotyped patterns common to many past grazing studies should be viewed askance.

22. Negative results and mistakes can provide usable information, particularly for planning new research, and an effort should be made to make it available to others.

23. Range research might profit by recruiting a higher proportion of its scientists from related disciplines other than conventional range management.

24. More use should be made of "critiques" by small groups of scientists to evaluate specific research plans and progress.

Bohning, John W. and S. Clark Martin. 1956. One Rancher's Experience - In the Grassland Range of Southern Arizona. Journal of Range Management, 9(6): 258-260, illus.

The ranch we are writing about lies near the Mexican border in southern Arizona in some of the best grass country in the West.

The average annual precipitation is 18 inches, of which about 14 inches comes during the frostfree period.

Cattle on the ranch are all purebred Herefords. The essentials of the livestock breeding program are 50 cows per bull, permitted by the gentle topography, with a breeding season from April 1 to September 1. Average replacement age for cows is 9 years, the average length of service for bulls, 7 years, and heifers are first bred at 24 months of age. This breeding program has resulted in 90 percent or better calf crops. When marketed in November, calves have consistently average 550 pounds over the last 15 years.

The cows are fed an average of 2 pounds of cottonseed cake daily from about January 1 to April 15.

The primary objectives of the range management program are: (1) to establish and maintain adequate ground cover in order to minimize loss of water by runoff and loss of soil by erosion, (2) to provide adequate year-round forage, thereby insuring better condition of the cattle and reducing the amount of needed supplemental feeding, and (3) to distribute grazing use to prevent the development of "sore spots" and to eliminate areas of nonuse.

Over a period of years, the range has been divided into 11 pastures. Each pasture has at least two watering places, usually one well and one or more ponds. The size of the pastures has been determined somewhat by topography and other natural barriers and also by the objective of having each pasture carry about 50 cows.

The present rate of stocking is 20 surface acres per cow yearlong. This rate normally leaves at least half the herbage for range improvement and maintenance. Deferment of use during the growing season has also promoted improvement of the perennial grasses. The only exceptions to this procedure are during years of severe drought. In order to hold utilization to a safe level in drought years, all pastures are grazed yearlong. The extra forage provided by no deferments helps maintain the breeding herd without excessive use of the range. It has never been necessary in over 25 years of this rancher's experience to remove cattle from the range for lack of forage.

One of the benefits that has been achieved is the establishment of an excellent stand of a wide variety of perennial grasses. The percentage

of tall grasses or bunchgrasses has increased at the expense of such short grasses as curlymesquite and blue grama.

The results of 30 years of study and practice on the range are clearly evident: (1) with the good grass cover, very little moisture is lost by runoff, (2) the droughts don't seem to hit so hard as on ranges that are not so well managed; the short grasses no longer predominate, but are still present on a healthy mixture, and (3) sore spots around permanent waters are small and the soil is staying in place.

Briggs, H. E. 1934. The Development and Decline of Open Ranching in the Northwest. Miss. Valley Hist. Rev., 20:521-536.

The early cattle industry on the ranges of Wyoming, Montana, and Dakota grew out of the needs of immigrants, military posts, Indian agencies, and mining camps for stock and fresh beef.

After the Civil War the cattlemen of Texas, facing the problem of over-stocked ranges and the lack of suitable markets, began to look for relief. Lured by good prices and available ranges, they were soon moving their longhorns northward in considerable numbers.

In spite of unfavorable business conditions in the early seventies, the process of stocking the available ranges of Wyoming went on unabated. The number of cattle in the territory increased from 90,000 in 1874 and 530,000 in 1880.

A demand for cattle in the stock growing areas of southwestern Montana coincided in time with the early Texas drives and small herds of southern cattle were driven into the territory.

In the early seventies, the cattle used in the southeastern portions of Dakota were raised by the frontier farmers or driven in from Iowa, Minnesota, or Texas. With the discovery of gold in the hills in paying quantities and the opening of that area to settlement in February 1877, a new field of operations was presented to ambitious cattlemen.

Stock in the hills area increased eighty percent in 1880 and one-hundred percent in 1881; while 100,000 head were marketed in 1881.

By the late seventies, open range ranching had made a good start in portions of the Northwest, although its expansion into northeastern Wyoming, central and eastern Montana, and northwestern Dakota was being held up since that region was still Indian country and had no railroad connections with the East. Although the battle of the Little Bighorn in 1876 and subsequent events made this area comparatively safe from hostile Indians, the region was not officially evacuated until 1880 and 1881, when the tribes were gradually moved to the Standing Rock Reservation in Dakota.

General conditions in the early eighties were ideal for the development of the great cattle boom. The financial depression of the seventies was over; and capital, both domestic and European, was available at reasonable rates of interest. Western steers sold in the Chicago market for high prices and would be finished on the western cattle ranges at a small cost.

The period from 1880 to 1886 was marked by an enormous expansion of the ranching business, a sharp increase in the amount of capital invested and overcrowding of the ranges. During these years the demand for cattle on the ranges was greater at times than the available supply. In addition to the Texas longhorns that were brought in by the thousands, cattle were moved northward out of Colorado in large numbers and some were brought in from Washington, Oregon, and northern Idaho. More significant, however, was the shipment of young breeding stock and stock steers from the farms of Wisconsin, Minnesota, Michigan, Illinois, Iowa, and Missouri. From 1882 to 1884 there were probably as many cattle shipped West as were received in the East.

Between 1880 and 1886 every available bit of range in central and northeastern Wyoming was occupied with a startling rapidity. In many of the counties, the increase between 1880 and 1883 was more than five-hundred percent. Many large cattle companies were organized.

At the same time, the range country of central and eastern Montana was quickly filled to overflowing. Open range ranching had become well established in the Black Hills district in southwestern Dakota in the late seventies. During the boom period, Dakota received many more Texas cattle than did Montana.

Good profits made in the early years of the boom attracted eastern and European capital and large cattle companies became common. Many pioneer ranchers were induced to sell their holdings to the large promoters or to exchange them for capital stock in newly organized companies able to furnish additional funds for further expansion. The price of cattle reached its peak in May 1882, when the last steers sold on the Chicago market for $9.35 per hundred. There was a rapid decline, especially in the lower grades, from $4.25 in April 1883, to $1.00 in the fall of 1886.

The decline in profits resulted in closer attention to costs of transportation and marketing and unsuccessful efforts were made to force the railroads to reduce rates and improve their service. The development of the refrigerator car in the seventies and increasing costs on the range led to the experiment of the Marquis de Mores, who established a complete packing house at Medora, Dakota, in 1883, and lost more than a million dollars in the venture. By 1885, two points were clear regarding the open range cattle business in the Northwest. In the first place, it was ceasing to be a frontier industry; while in the second, it was falling a victim to overexpansion. Although ranching continued to have a frontier environment, with the danger, hardship and isolation of earlier years, it was coming to be largely controlled by company offices in eastern cities. Although the small operator had not disappeared, it was becoming more and more difficult for a man of limited means to remain in the business.

Cattle raising under the open range system, dependent as it was upon weather conditions, had always been recognized as hazardous. Each

spring, losses were counted and the rancher felt relieved if fortune was with him. Somewhat of a gamble under normal conditions, the throwing of hundreds of thousands of young eastern stock upon an already overstocked range greatly increased the risk.

The winter of 1880-1881 had been quite severe on the northern ranges and losses had been heavy in central Montana and in parts of Wyoming. The Black Hills Stock Association reported a loss of only eight to ten percent, most "through" stock. The following winters were mild and the losses of 1880-1881 were soon forgotten as the boom gained momentum. When the news arrived of the enormous losses in western Kansas and Colorado the better informed and more conservative became uneasy and realized that only sheer luck had saved them.

The summer of 1886 was dry and warm. Hot winds sweeping over the range shriveled the grass and dried up the creeks and waterholes. By the first of June, herds were being moved where water was obtainable. Conditions were worse in central and eastern Montana than in Dakota and Wyoming. With Texas and eastern cattle arriving during the summer, conditions were indeed serious. To make matters worse, the price of cattle was extremely low in the fall of 1886.

The story of the calamitous winter of 1886-1887 has been told many times. It closed down from the northwest fully six weeks earlier than usual, holding the cattle ranges in its iron grip for more than four months, relaxing at last only to leave ruin and desolation in its wake.

Early in March a "chinook" loosened the icy grip of winter and melted the snow at a rapid rate. Within a few days, the creeks and rivers were carrying countless dead cattle down stream amid cakes of ice and debris. One observer describing the Little Missouri tells how the sudden stream spewed forth the carcasses of cattle in untold thousands and "one had only to stand by the river bank for a few minutes to realize the depth of the tragedy that had been enacted." Estimates of losses vary from as low as 80 to as high as 92 percent.

Many of the large companies went into the hands of the receiver in the summer of 1887 and disposed of the remnants of their herds, as their creditors demanded payment.

Large herds were no longer turned loose without shelter to graze and drift where they willed. Herds were smaller and kept under careful control, shelter being provided for the weaker animals and hay cut for emergency feeding.

In the meantime, the agriculturalist and the rancher were having difficulties. In the late seventies and early eighties as the line of settlement advanced westward, frontier farmers slowly filtered into Wyoming, Montana and Dakota close to the ranching areas and located their homesteads.

Thus, by the early nineties, the open range had disappeared in the Northwest except in a small area of northeastern Montana, where it lingered on for another decade. Although the cattle business continued as an important industry, the great outfits of the boom period had been eliminated and ranching methods had undergone a complete change.

Bureau of Land Management, USDI. 1951. Rebuilding the Federal Range. Pp. 8-11, Processed.

The Federal rangelands still bear many of the scars incurred during decades of unregulated grazing use. The normal wearing down and building up of the earth's surface known as geologic erosion has been speeded up by partial removal and change in the protective plant cover. Deterioration of about half of the total range area has progressed to a point where range management alone may not protect the land from further depletion or restore it to its original productiveness. Special land treatment measures must supplement range management to halt accelerated soil erosion and secure a permanent cover of vegetation.

According to the best estimates now available, about 50 percent of Federal rangelands are in a state of severe to critical erosion, 32 percent are eroding moderately, and only 18 percent are in a condition of slight to no erosion. Thus the major portion of Federal rangeland is contributing to downstream sedimentation and presents some of the most critical watershed problems of our western river basins.

The heavy toll of range soil taken by wind and water erosion is largely the result of a depleted plant cover. Perennial grasses and browse plants affording the greatest protection to the soil have been removed through drought, overuse and fire. Their removal has encouraged the invasion and spread of undesirable brush and trees until many millions of acres of once productive rangeland are occupied today by sagebrush, mesquite, or junipers.

These species furnish little protective cover for the soil and lack the mulch-producing qualities of grasses. Instead, the soil between the plants is exposed to the erosive forces of wind and water. The porous topsoil is soon eroded away leaving a pavement-like surface rendered even more impervious by the scaling effect of silt particles. Rain or snow falling on these areas have little opportunity to penetrate the soil in amounts adequate to promote the reestablishment of grasses without the help of artificial methods.

It is estimated that the average annual runoff from Federal ranges in the major river basins of the West is 23 million acre-feet of water, or only about 5 percent of the total annual flow of the streams in the States west of the Mississippi. On the other hand, it is estimated that Federal rangelands produce 320,000 acre-feet of sediments annually--exceeding the combined volume of sediment discharged by the Mississippi and Colorado Rivers. Converted to a weight basis, the annual sediment loss is equivalent to nearly 500 million tons of soil. To transport this volume by rail would require 244,846 trains of 50 cars each, with each car carrying a load of 40 tons. From a watershed

standpoint, therefore, we find the Federal rangelands yielding a minor volume of usable water but producing a major portion of the sediment in western river basins.

The most important step in the rebuilding of deteriorated ranges to maximum productivity is adequate management. Management includes the regulated use of the range in such a manner that numbers of livestock do not exceed the grazing capacity of the range. Equally important is supervision to insure that livestock is grazed only during the proper season and is properly distributed over the range to avoid excessive use in some areas and underuse in others.

If not damaged greatly, the ranges have considerable natural recuperative powers which, when given a chance, will respond to regulated use. When not overused, range plants regain their normal vigor, regenerate rapidly, and produce sufficient foliage to provide protection for the soil. Ranges in an advanced state of deterioration may have to be excluded temporarily from grazing use while restorative practices are applied.

Range improvements, such as those illustrated above, play an important part in facilitating desirable range management practices. The location of livestock watering places is given primary consideration in obtaining proper distribution of animals on the range and securing uniform utilization of the available forage. The distance between watering places varies with the topography and the nature of the range. In rough country, the ideal distance between water should not exceed 1 mile. In level country, the distance may be increased to 3 miles and still obtain satisfactory use of the forage.

Burnett, George L. 1966. Opportunities for Intensive Grazing on Federal Lands. Abstracts of papers presented at the 19th Annual Meeting, ASRM, pp. 48-49.

Many Western stockmen, still active in beef production, can remember all public domain open to grazing on a first-come, first-serve basis. The grazing lands were managed to round out yearlong operations without much interference, or thought of interference, by other interests, and both the rancher and the ranger on the National Forests were optimistic about long-time grazing capacities. An "intensive grazing system," as we define it today, was just an abstract term in someone's dictionary.

All had been trained not to "waste" feed. There were progressive individual operators who led the way to conservative grazing, but they were the exception. Feed shortages, when recognized, could always be corrected by more rain, a few miles of trail into an unused pocket of grass, a short drift fence, a new water development, or a little more riding.

Later, actual capacities under those management practices were assessed and recognized. The solution recommended by the ranger to stop overgrazing was to reduce livestock numbers and seasons of use. This formula generated controversy, bitter arguments, and hard feelings - many of them.

In one section of country I am familiar with, both stockmen and Forest officers tired of the continual wrangle and distrust. They decided to start cooperating to see what could be worked out together. They also agreed to try this "new (?) fangled" idea of "rotation."

Progress, using the committee approach, was slow at first but speeded up as know-how and cooperation were pooled. Physical improvements, such as noxious plant control, additional water development, and fenced management boundaries, were recognized as tools to use in increasing forage production. New problems arose. "How many more livestock shall we graze?" and "Can we put our hands on $5,000 to build 3 more waterholes and 4 miles of fence across that gap?"

The parent Range Improvement Committee gained in stature and know-how. Their range improvement recommendations now are sought after and heeded. The cooperative practice has spread. Each range is evaluated and treated on an individual basis.

Greatly simplified, the cooperative approach has three good, sound, selfish reasons for working: (1) range production goes up, (2) permittee likes it, and (3) the forest officer likes it.

The opportunity for additional improved ranges on Federal land is almost unlimited.

Campbell, J. B. 1961. Continuous Versus Repeated-Seasonal Grazing of Grass-Alfalfa Mixtures at Swift Current, Saskatchewan. Journal of Range Management 14(2):72-77, illus.

The site was fall cultivated in 1953, and sown to the grass alfalfa mixtures (crested wheatgrass, Russian wildryegrass, intermediate wheatgrass, and a local creeping-rooted strain of alfalfa) in 12-inch spacings during May 1954. A wheat companion crop was grazed during August and September. In 1955 the grass-alfalfa mixtures were cut for hay. Grazing commenced in May 1956 and continued through 1959.

Treatments were as follows:

No.	Crop	Treatment	Acreage
1	Crested wheatgrass Alfalfa	Spring through autumn	3.6
2	Intermediate wheatgrass Alfalfa	Spring through autumn	3.6
3	Russian wildryegrass Alfalfa	Spring through autumn	3.6
4a	Crested wheatgrass Alfalfa	Spring only	1.2
4b	Intermediate wheatgrass Alfalfa	Mid-summer only	1.2
4c	Russian wildryegrass Alfalfa	Autumn only	1.2

Yearling Rambouillet ewes were placed on Treatments 1, 2, 3, and 4a during early May. Continuous grazing was practiced on Treatments 1, 2, and 3 for 120 to 160 days. In the seasonally grazed paddocks the flocks were moved from 4a to 4b to 4c as the feed supply disappeared; each was grazed once a year. Stocking rates were set at $2\frac{1}{4}$ ewes per acre.

Greater-than-average rainfall and satisfactory soil moisture reserves in 1954 and 1955 produced vigorous stands. However, the less-than-average precipitation from 1956 through 1959, together with reduced soil moisture reserves, were factors which reduced ground cover and yield. Specifically, the less-than-average rainfall during May and early June from 1957 through 1959, caused drought conditions which were reflected in the reduced production during 1958 and 1959.

The thirty-seven year average annual precipitation for the site was 13.9 inches. Precipitation for the May to July period averaged 6.4 inches for the same period.

No significant differences were established between treatments on the basis of pasture production trends, apparent consumption per acre or per ewe, sheep days per acre, apparent consumption per pound gain, or stocking rate.

A Russian wildryegrass-alfalfa-sward grazed from early May through mid-October was outstanding in stand maintenance and line-weight gains per ewe and per acre. Equal in stand maintenance and grazing capacity, but significantly lower in line-weight gain per ewe and per acre was a continuously grazed crested wheatgrass-alfalfa pasture.

The intermediate wheatgrass-alfalfa pasture produced well during the first two years. However, winter-killing of the grass after three years of grazing reduced the productivity of the sward. Although the loss of the grass is attributed to winter-killing, undoubtedly the grazing treatment predisposed its disappearance.

The creeping-rooted strain of alfalfa used in this test maintained its stand in the spring grazed paddocks and persisted strongly in the autumn pastured fields, but decreased on the continuously and summer grazed pastures.

"A repeated seasonal pasture employing the crops listed in Treatment 4 cannot be recommended over continuous pasturing of Russian wildryegrass-alfalfa or crested wheatgrass-alfalfa pastures."

Campbell, J. B., R. W. Lodge, A. Johnston, and S. Smoliak. 1962. Range Management of Grasslands and Adjacent Parklands in the Prairie Provinces. Canada Department of Agriculture, Research Branch, Publication 1132, 32 pages, illus.

Domestic livestock have grazed native grasslands of the Canadian prairies for over 80 years. During this time there have been periods when grass was abundant and others when it was scarce. The supply of grass has depended on precipitation. The cover improved when rainfall was abundant, but deteriorated when there were two or more dry years together.

Ranchers were the first to study the prairie grasses. They realized the low grazing capacity of the native grasslands and the need for feed reserves to maintain herds and flocks through the long, cold winters and the occasional very dry summers.

Dryland farming expanded rapidly after 1900. During the period of adjustment the grasslands were used heavily and often overgrazed. Research began in 1927 at the Range Experiment Station, Manyberries. Later, grazing studies were undertaken in the foothills of the Rocky Mountains and in the Great Sand Hills of western Saskatchewan. Grazing surveys have been conducted since 1937 to estimate the carrying capacities of the different types of grassland.

The climate of the region is cool and semi-arid. Winters are long and cold; summer rainfall is low and variable. Records collected from 6 locations in the Canadian prairies indicated the mean annual precipitation to vary from 12.0 inches to 18.2 inches, depending on the locality. May through July precipitation varied from 5.2 to 8.3 inches.

Five grass associations or types are found in the prairies: short-grass, mixed-grass, true prairie, tall-grass prairie, and fescue prairie.

Grazing methods:

1. Continuous from 6 to 10 months. From time spring storms are over until snow prevents foraging.

2. Deferred until flowering of well-known plants.

3. Two principal pastures, one for summer and a second for winter.

4. Subdivide the summer range into two fields and graze each every second year with twice the livestock load.

5. Rotate cattle in a spring-summer and a summer-fall system.

6. Divide the summer range into three fields and use each for about one-third of the grazing season.

A few of these systems have been studied in grazing tests. The results show that one field grazed continuously produces as much or more beef than two or three grazed in rotation at the same rate. These results apply on short-grass and mixed prairies, and (Table 6) on cultivated grass-alfalfa pastures in the mixed prairie zone. None of the above-mentioned systems has marked advantages, although the grass cover is usually greater when rotations are practiced and the livestock gains per acre are higher for continuous pasturing. Rotational grazing helps the grass because the plants can set seed and maintain food reserves.

Table 6 --COMPARISON OF CONTINUOUS GRAZING AND DEFERRED GRAZING ON THREE FIELDS IN ROTATION

Item	Liveweight gain per acre Lb.		Grass Cover %	
	Continuous Grazing	Deferred Rotation	Continuous Grazing	Deferred Rotation
Short-grass prairie[1]				
Steers	8.7	8.0	7.2	7.4
Cows and calves	13.2	11.8	7.4	8.2
Grass-alfalfa pasture[2]				
Yearling ewes	50.0	42.2	7.3	7.6

[1] Manyberries, Alta., 9-year test.
[2] Swift Current, Sask., 5-year test.

A test at Swift Current has shown the value of grazing crested wheatgrass and native grass in rotation on mixed prairie (sandhill type). The crested wheatgrass was grazed until late June and the native grass from then to mid-October. This sytem carried 35 percent more animals and produced 6 percent more daily gain per steer than when native grass only was grazed from May to October. Further, the pasture of native grass alone was grazed too heavily, but there was no sign of overuse on the native grass that was protected until late June.

Canfield, Roy H. 1939 (Revised 1940). Semi-Deferred Grazing as a Restorative Measure for Black Grama Ranges. Southwestern Forest and Range Experiment Station, Res. Note #80, 4 pages.

The purpose of this note is to describe one of the methods which has been proven successful by experimentation in the restoration of depleted black grama ranges on the Jornada Experimental Range in southern New Mexico. The pasture in which this experiment was conducted is representative of the black grama type which is commonly spotted with tobosa grass (Hilaria mutica) flats on the heavier soils. The black grama areas are not pure stands but contain, in addition to black grama, a mixture of summer palatable grasses. These are principally sand dropseed (Sporobolus spp.) and threeawn grasses (Aristida spp.).

The method of range management here discussed is generally referred to as semideferred grazing. More precisely, the system is one that is based on the partial deferred use of black grama. A major part of the black grama is reserved for winter use by a system of lighter summer stocking and by the distribution of the cattle in a way that will encourage them to graze less of the black grama and more of the seasonally usable companion grasses. Such summer palatable grasses usually are associated with black grama in the black grama type and often occur in pure stands on small areas included within the black grama type.

Below-par black grama ranges show improvement under properly regulated semideferred grazing. The next 14 years (1922 to 1935, inclusive) of experimentation with semideferred grazing were more productive of positive results. Stocking was regulated with a wider difference between summer and winter use. For each 100 head grazed in the pasture during the summer, 156 head were grazed in winter. Rainfall for the 14-year period was: lowest year - 5.18 inches; highest year - 17.73 inches; with a period average annual of 9.29 inches. The perennial grasses increased their density from 141 cm^2 in 1921 to 446 cm^2 at the close of the growing season in 1934.

Semideferred grazing provides for the utilization of seasonally palatable forage. With semideferred grazing the pasture is never completely deferred by being cleared of all stock. Although a number of plants are palatable for but a short time during the growing season, they can be utilized during the period of highest usability because a sufficient number of animals are left in the pasture to consume them.

Availability of seasonally usable plants is a matter of considerable moment in the operation of ranches in southeastern Arizona, southern New Mexico, and western Texas. On these ranches the sparsely growing browse, yucca blooms, and scattered annuals produced under a "spotted" distribution of summer rainfall may be needed to carry the stock through a short but extremely difficult period.

Chapline, W. R. 1919. Production of Goats on Far Western Ranges. U.S.D.A., Bulletin No. 749, 35 pages, illus.

On far western ranges goats are raised mainly for mohair and meat and secondarily for milk and hides. On farms they are valuable also for clearing brush. The possibility of clearing brushy areas by heavy stocking with goats and the excessive overgrazing and injury to the range which has resulted on many goat ranges from lack of proper management have created the impression that goat grazing cannot be conducted without unwarranted damage to range and timber reproduction. Furthermore, a lack of proper selection, care and management of the range goats has resulted in a low average production of mohair and meat and small profits. There are individuals, however, who have improved their methods of management for the range and the goats so that they have eliminated overgrazing and injury to the range and established a profitable business. The adoption of similar improved methods more generally by range goat growers would greatly decrease injury to the range and to tree growth and watersheds where these are factors, and would place the range goat industry upon a more stable and remunerative basis.

More goat ranges are used throughout the year. This and the general practice of driving the goats out from a corral at the ranch headquarters and back every day for months or throughout the year have been largely responsible for such a deterioration of the range as to cause a widespread belief that any grazing by goats is extremely destructive to range. The fault is largely in the method of management, which with large herds is sure to concentrate grazing to the point of overstocking and to cause continued premature grazing. Where a similar practice has been followed in the management of cattle and sheep, the range has been similarly depleted.

The remedy lies in working out a plan of grazing which will give the vegetation a chance to grow sufficiently to maintain itself. To do this on an area which is grazed throughout the year necessitates light stocking, at least during the main growing season of the important forage plants. Investigation and practical tests have shown that a better plan is to divide the range into three areas, one for spring, another for summer and fall, and a third for winter. Dividing the range for seasonal use so as best to meet the needs of the forage and of the goats and distributing the grazing more evenly over the range make possible the maintenance of the forage under heavier grazing and the reservation of suitable feed for the most critical periods of the year.

Range suitable for goats should possess a mixture of browse, grasses, and weeds, be free from continued heavy rains and snows, and be well supplied with bed grounds and watering places.

For proper management of any goat range the forage should be utilized in such a manner as best to meet the needs of range and goats. The entire range should be divided for seasonal use into three parts, spring range, summer and fall range, and winter range. The grazing on these divisions should be of such intensity and distribution as to secure a uniform utilization and to allow the forage to make sufficient growth to maintain itself.

The spring range must necessarily be grazed heavily at that time, but it should not be overstocked and should be protected from grazing at other times of the year.

The summer-and-fall range, containing the forage at the higher elevations, must usually be grazed during the growing period of the vegetation. The grazing, accordingly, should be well distributed and should be deferred until after seed maturity on successive parts of the division so as to insure proper revegetation.

The winter range, located on areas low enough to avoid severe storms, should be reserved for winter grazing only, in order to insure an ample supply of suitable winter forage. The grazing should be well distributed over the division, and the range close to the sheds should be reserved for use during stormy periods only.

Overgrazing causes deterioration of the range, erosion, injury to timber reproduction, and impairment of the growth of goats and mohair. Excessive overgrazing may even cause serious loss and suffering among the goats at critical periods. The number of goats should be regulated so as to prevent overgrazing.

Clarke, S. E., E. W. Tisdale, and N. A. Skoglund. 1943. The Effects of Climate and Grazing Practices on Short-Grass, Prairie Vegetation in Southern Alberta and Southwestern Saskatchewan. Canada Dominion Exp. Sta. Publication No. 747, Tech. Bull. No. 46, 53 p.

This bulletin presents the results obtained in studies of the native vegetation and its utilization at the Dominion Range Experiment Station, Manyberries, Alta., during the period 1928 to 1939, inclusive. Projects conducted at this Station included studies of the response of cattle to various range management practices as well as investigations of the plant cover.

Precipitation during the years 1928 to 1939 averaged 10.7 inches annually, with half this amount falling during the period April 1 to July 31.

The vegetation of the area consists of a xeric phase of the mixed prairie designated as short-grass prairie. The principal species in relative order of basal area occupied are Bouteloua gracilis (grama grass), Stipa comata (speargrass), Agropyron smithii (western wheatgrass), Koeleria cristata (Junegrass), Poa secunda (Sandberg's bluegrass), and Carex filifolia (niggerwool).

A 7-year test of grazing capacity was made at intensities of 20, 30 and 40 acres per head respectively for the 7-month grazing season (April 1 to October 31). Results indicated that the true grazing capacity of the area studied was slightly more than 30 acres per head. At the rate of 20 acres per head the cattle failed to make normal gains, while the plant cover showed signs of deterioration. The mid-grass species such as Stipa comata suffered more from heavy grazing than did Bouteloua gracilis and other short-grass forms.

During the period 1932 to 1937 deferred and rotational grazing at rates of 20 and 30 acres per head for the 7-month grazing season was tested in comparison with continuous grazing at these rates. The rotation involved the use of three fields of equal size, and the division of the grazing season into three approximately equal periods. Results indicated that the rotation was superior to continuous use so far as effects on the plant cover were concerned. The vegetation of the fields grazed in rotation at the rate of 30 acres per head suffered little deterioration in spite of unfavorable climatic conditions. No apparent advantage to the cattle was derived from the rotation. However, the experiment was not conducted for a sufficiently long period for the full effect of the system to be determined.

Studies were made of the effect of various practices on the maintenance of the forage cover both on the experimental area and in other parts of the short-grass prairie area. The effects of overgrazing

were found to consist chiefly of a progressive decrease in the abundance, vigor and yield of the more palatable species, associated with a corresponding increase in unpalatable weeds. Soil erosion and damage due to trampling by livestock and to the depredations of rodent and insect pests were all increased under overgrazed conditions.

Burning of range pastures in either spring or fall caused reductions in forage yield, and from 3 to 5 years was usually required for complete recovery under conditions of moderate grazing.

Cole, John S., F. L. Kelso, E. Z. Russell, J. B. Shepherd, Duncan Stuart, and R. R. Granes. 1927. Work of the United States Dryland Field Station, Ardmore, South Dakota, 1912 to 1925. U. S. D. A. Tech. Bull. #17, 68 pp., illus.

The United States Dryland Field Station, Ardmore, South Dakota is situated near Ardmore, Fall River County, South Dakota, 2 miles north and 18 miles east of the southwest corner of the State. The soil and climatic conditions at the station are representative of those of a large area in southwestern South Dakota, northwestern Nebraska, and eastern Wyoming.

The first impulse given to general settling in the area under consideration was the construction of the Chicago, Burlington & Quiney Railroad between Omaha, Nebraska, and Billings, Montana, in the late eighties. Prior to that time the country was used almost exclusively as an open range by large cattle companies. There were some settlers and squatters along the creek bottoms who made more or less spasmodic attempts at crop cultivation, but the chief industry was raising beef cattle on the open range. The little available history of the economic conditions of the country clearly indicates that this was a profitable and comparatively safe system of utilizing the natural resources.

The homesteader followed closely the advent of transportation facilities. Most of the early settlers had neither capital nor training to undertake, with a reasonable expectation of success, the systematic development of an agricultural program of either grain farming or livestock production. Their efforts at farming were usually confined to breaking and putting into a rather inferior state of cultivation the limited area required by the homestead regulations. Crops were planted without knowledge of their adaptation to the soil and climatic conditions or of the methods required. Many of the immigrants brought with them seed from other States, where the soil and climate were entirely different. Crop failures were frequent. The settlers had few or no livestock with which to supplement their income from crop production. Individual economic disasters were common, and many hardships were suffered. Most of the first settlers stayed in the country only a few years. Many obtained loans on their homesteads as soon as patents were granted and shortly afterwards left the country, with the result that in the aggregate large acreages of land came into the ownership of the companies making the loans.

As in other sections of the Great Plains, settlement was frequently stimulated by a series of good years which gave an exaggerated idea of crop possibilities, and depopulation was the result of a series of poor years.

It has only been during recent years that anything like a uniform and stable agriculture has developed. Stock raising, supplemented by grain farming, is now practiced more extensively than is any other system, but many individuals still utilize their entire acreage for grazing livestock and do not even attempt to grow a garden or to produce feed on a small scale. Such ranchers depend upon native hay for winter feed and frequently are compelled to ship in feed when the winter conditions are exceptionally severe. The results of the experimental work at Ardmore clearly indicate that this system adds unnecessary expense and hazard to the farming operation.

Increase in the number of livestock in the country has developed new problems in the production of feed. The grazing season is comparatively short, and the winters are often long and severe. There is also great variation in the length of either season. Under the old system of livestock production, beef cattle depended almost entirely upon the open range for feed during the winter as well as the summer months.

The soil at the Ardmore station, as the analysis of a sample collected in 1920 indicates, is of a medium to dark brown color and clay-loam texture to a depth of about 15 inches. A zone of lime-carbonate accumulation encountered at this depth extends to about 2 feet in depth; below it lies the parent material, ranging from clay to gravelly clay, which had accumulated by deposition from river water.

The annual precipitation at Ardmore during the period covered by these investigations has varied from about 12 to 30 inches and averaged 16.43 inches. About 70 percent of the precipitation occurs during the growing season from April to August, inclusive, and nearly 80 percent during the six months from April to September, inclusive.

The temperature at Ardmore is characterized by extremes in both winter and summer. The lowest temperature recorded was -34°F., on January 11, 1916; and the highest temperature was 103°F., on seven days -- July 28, 1917; June 29, 1919; July 25, 1919; July 22, 1920; June 22, 1922; August 2, 1924; and July 13, 1925. The coldest months are January, December, and February, in the order named. The hottest months are July, August, and June, in the order named. Hot winds frequently accompany periods of high temperatures.

The steer-grazing experiment here reported was conducted in cooperation with the Animal Husbandry Division, Bureau of Animal Industry.

The country surrounding the Ardmore station is adapted primarily to the grazing of beef cattle, and for many years stock raising was the chief agricultural industry. The open range was used without any definite plan of pasturing, but a combination of factors resulted in a fairly uniform practice throughout the country. The buffalograss and blue grama grass have a thicker basal cover and furnish green pasture earlier in the spring than does the western wheatgrass, which predominates in

the lowlands and valleys. Water also is plentiful in the uplands early in the season, but it becomes scarce as the season advances. During the spring and summer months the herds of cattle were moved from place to place as the season advanced. A herd of cattle was kept for two or three months in one locality and then moved to another as the grass in the first section became too short for further profitable grazing. In the late fall the herds were moved to the creek bottoms and valleys, where the trees and hills afforded some protection from the severe winters and where native hay might be available for feeding if necessary.

In recent years the open range has been greatly restricted by the advent of the homesteader and the consequent fencing and cultivation. As a result of the restriction of the range and the development of smaller units, pasturing is continuous on the same land. It is a matter of common knowledge that the native vegetation has been unfavorably affected by this method, and range land that at one time provided a large amount of pasture is now furnishing much less.

The country is commonly known as a short-grass country because of the abundance of low-growing grasses. The native vegetation of this area is composed of a large number of plant species. The dominant species are buffalograss (Bulbilis dactyloides), western wheatgrass (Agropyron smithii), and blue grama grass (Bouteloua gracilis). These three grasses make up more than half of the vegetation utilized by grazing animals. Some of the other plant species that are common in this area are Sheldon bluegrass (Poa sheldonii), Pasoraleu tenuiflora, sagebrush (Artemisia tridentata), pasture sagebrush (A. frigida), prairie June-grass (Koeleria cristata), and several species of vetch (Astragalus sp.).

Buffalograss and blue grama grass are common and abundant on the higher lands and furnish grazing throughout the season. Western wheatgrass is also common on the higher lands, but it makes its best growth on the lower lands and in the valleys. It does not furnish as much or as good grazing as the buffalo and blue grama grasses. It makes hay of excellent quality and on the lower lands is utilized for that purpose.

With the history of the country in mind, an experiment was planned to study the effects of different methods and intensities of grazing upon the cattle and upon the native vegetation to determine the area required to carry a given number of cattle through the grazing season and to study the methods of improving or maintaining in a state of profitable production pastures that have begun to show the effect of overgrazing. The plans for the experiment were completed and the necessary fencing done in 1917, but cattle were not available in 1918 until in July. This allowed grazing for only a part of that season. Grazing for the full summer season usually begins about the middle of May and ends in September or October.

TABLE 15 -- Gains of the steers in each of three pastures at Ardmore, South Dakota, during the seven years 1919 to 1925, inclusive.

Pasture and Year	Steers (number)	Period Grazed	Monthly Gains or Losses						Seasonal Gains				Average daily gains per head
			May	June	July	Aug.	Sept.	Oct.	Per Pasture	Per Head	Per Acre	Per 100 lbs. of live weight	
		Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
150 acres:													
1919	10	145	350	1,435	215	95	320	-260	2,155	215.5	14.4	25.7	1.49
1920	10	145	325	895	1,775	285	420	160	3,860	386.0	25.7	52.1	2.66
1921	14	140	420	1,200	825	19	451	-180	2,735	195.4	18.2	39.0	1.40
1922	11	130	700	1,100	540	-10	700	--	3,030	275.5	20.2	40.4	2.12
1923	15	150	--	960	555	1,010	600	-420	2,705	180.3	18.0	36.6	1.20
1924	10	130	-118	1,080	435	280	111	--	1,788	178.8	11.9	23.0	1.38
1925	10	130	-175	935	715	385	20	--	1,880	188.0	12.5	24.3	1.45
Average	11.4	139	250	1,087	723	295	375	-175	2,592	231.2	17.3	34.4	1.67
80 acres:													
1919	10	145	510	1,030	475	675	-335	-265	2,090	209.0	26.1	24.4	1.44
1920	10	145	290	1,285	1,170	310	345	-155	3,245	324.5	40.6	43.9	2.24
1921	14	140	575	1,070	580	139	71	-275	2,160	154.3	27.0	30.6	1.10
1922	11	130	390	1,095	635	355	-200	--	2,275	206.8	28.4	30.9	1.59
1923	15	150	--	930	690	690	15	-825	1,500	100.0	18.8	20.6	.67
1924	10	130	-205	1,000	170	-135	-425	--	405	40.5	5.1	5.2	.31
1925	10	130	-5	810	615	200	-265	--	1,355	135.5	16.9	17.4	1.04
Average	11.4	139	259	1,031	619	319	-113	-380	1,861	167.2	23.3	24.7	1.20
160 acres:													
1919	20	145	980	2,035	-145	1,180	70	-935	3,185	159.3	19.9	18.7	1.10
1920	20	145	1,015	2,480	2,065	690	840	-290	6,800	340.0	42.5	46.0	2.34
1921	28	140	1,310	1,880	140	1,129	391	0	4,850	173.2	30.3	34.4	1.24
1922	24	130	1,155	2,230	805	1,190	390	--	5,770	240.4	36.1	35.5	1.85
1923	32	150	--	2,000	1,105	1,510	745	-1705	3,655	114.2	22.8	23.4	.76
1924	22	130	-352	1,645	-545	1,375	-1215	--	908	41.3	5.7	5.3	.32
1925	16	130	-145	1,600	655	770	-80	--	2,800	175.0	17.5	22.9	1.35
Average	23.1	139	661	1,981	583	1,121	163	-733	3,995	177.6	25.0	26.6	1.28

- Minus sign shows loss

The pastures used for the experiment are located on land typical of the locality. Two of the three pastures are under a system of continuous grazing. They are, respectively, 150 acres and 80 acres in size. Another pasture of 160 acres is under a system of deferred and rotation grazing. This pasture, on account of its shape, was fenced in two divisions, instead of the three generally used for this system of grazing. One division of this pasture is grazed in the spring and the other in the fall for two years in succession, and then the time of grazing each pasture is interchanged for two years.

It was planned to use 2-year-old steers. The 150-acre and the 80-acre pastures were each to carry 10 steers, or 1 steer to 15 and 8 acres, respectively; and the rotation pasture was to carry 20 steers, or 1 steer to 8 acres. The determination of the size of the pastures was arbitrary, but it was based on the best information obtainable. The intent was to fix the size of the continuous pastures so that one would be fully grazed and the other undergrazed by 10 steers. It was not always possible to obtain 2-year-old steers, so 3-year, 2-year, and 1-year steers have been used. When yearling steers were used the number was increased in all pastures. The varying number and ages of the cattle complicate the study of the results, but could not be avoided.

The gains of the steers for each year of the period 1919 to 1925, inclusive, are presented in Table 15. The data for 1918 are not included because they were for only a part of the season.

The gains of the steers in the 150-acre pasture ranged from 178.8 pounds each for the 2-year-olds in 1924 to 386 pounds each for the 3-year-olds in 1920. The average gain for the seven years was 231.2 pounds each, or 1.67 pounds per day. The gains per acre ranged from 11.9 pounds in 1924 to 25.7 pounds in 1920, averaging 17.3 pounds for the seven years. This pasture has provided an abundance of feed, and the cattle in it have made greater gains each season than those in either of the other pastures. The larger gains per head over those in the other pastures are not proportionate to the greater acreage on which they were made, and consequently this pasture shows the lowest gain per acre. It is undergrazed and is not carrying the number of cattle it could support under a system of continuous grazing.

The gains of the steers in the 80-acre pasture ranged from 40.5 pounds each for the 2-year-olds in 1924 to 324.5 pounds each for the 3-year-olds in 1920. The average gain for the seven years was 167.2 pounds each, or 1.2 pounds per day. The gains per acre ranged from 5.1 pounds in 1924 to 40.6 pounds in 1920 and averaged 23.3 pounds for the seven years. This pasture has not provided feed enough to allow the cattle in it to make as great gains as are made in the other pastures. In the drier years the feed has been exhausted, and the cattle have suffered heavy losses in weight before the end of the season.

The rotation pasture of 160 acres is separated into two divisions. It was grazed with double the number of cattle in either of the other

pastures for the first three years, with two more than double the number for the next three years and with 16 head in 1925. The gains of the steers in it ranged from 41.3 pounds each in 1924 to 340 pounds each in 1920 and averaged 177.6 pounds for the four years.

The steers in this pasture each had the same area of land as those in the 80-acre pasture in 1919, 1920, and 1921, a smaller area in the next three years, and a greater area in 1925, but in all years except 1919 they made greater gains per steer. The seven-year average gains per steer in the rotation pasture are slightly higher than in the 80-acre continuous pasture, and the gains per acre also are higher. This excess in the gains has not been so great, however, as might be expected from a three-division system of deferred and rotation grazing.

No changes in the character of the vegetation can be observed as a result of the different methods and intensities of grazing. Even in the 80-acre pasture, which has been closely grazed every season and much overgrazed some seasons, there appears to have been very little change.

In 1922, data were obtained on the carrying capacity of 15 acres of native pasture. The same year three lots of 5 acres each were seeded to cultivated grasses; and these, with a fourth 5-acre lot of native pasture, were compared in 1923, 1924, and 1925. The grasses used in these experiments were as follows: (1) native pasture, composed of a variety of native grasses, principally western wheatgrass (Agropyron smithii), buffalograss (Bulbilis dactyloides), and blue grama grass (Bouteloua gracilis); (2) sweetclover pasture; (3) bromegrass pasture; and (4) crested wheatgrass (Agropyron cristatum) pasture.

The lands on which the native grasses and sweetclover were pastured were level to gently rolling, the latter portion covering only a small part of the whole area. The bromegrass and crested wheatgrass pastures were practically level. With the exception of a gravelly-clay outcrop in the gently rolling portions of the native-grass and sweetclover pastures, the soil was fairly uniform and was classed as a heavy, close-textured, clay soil.

The cows used in these experiments were purebred and grade Holsteins. Equality of production and weight between the groups was maintained as closely as possible. The cows were weighed twice each week, and daily records were kept of the milk and butterfat produced, the number of pasture days, the quantity of grain fed, etc.

One of the difficulties met with in the grazing of pasture grasses that are not indigenous to this locality is that the period most favorable to their growth is very short, usually extending through May and June. When dry weather sets in, very little growth is obtained; consequently, such grasses offer extremely short grazing seasons.

In order to determine the acre value of these pastures for the pasture season, the following method was adopted: a calculation was made of the quantities of digestible protein and total digestible nutrients necessary to maintain the cows at constant body weight and to furnish nutrients for the milk and butterfat produced. From the required nutrients thus calculated were deducted the nutrients in the grain and in any hay or silage that had been fed while the cows were on pasture. The difference is the weight of nutrients that may be credited to the pasture. This quantity of nutrients converted into the equivalent of alfalfa hay and corn silage when figured at local prices gives the value of the pasture. In other words, the monetary value of the pasture is figured in terms of the monetary value of the alfalfa hay and corn silage that would have been required to furnish an equal quantity of nutrients. Corn silage was valued at $6.50 a ton and alfalfa hay at $8 a ton.

The results thus obtained are shown in Table 26, which gives the kind of pasture, the dates of the beginning and the end of the pasture season, the cow-days per acre, the acres needed per cow per pasture season of 112 days, the milk produced per acre and per cow-day, the grain fed while the cow was on pasture, the equivalent of the pasture in terms of corn silage and alfalfa hay, and the calculated value of the pasture on this basis.

Table 27 is a summary of Table 26 and gives the calculated acreage required for an average pasture season of 112 days, and the value per acre of the four kinds of pasture used in the experiment. The requirements of crested-wheatgrass pasture was 2.73 acres per cow. More milk was produced by the cows when on this grass, thus necessitating the crediting of a greater quantity of nutrients per cow. The average value of the alfalfa hay and silage calculated as necessary to replace this pasturage was $1.07 more per acre than that of the sweetclover pasture and $0.95 more than that of the bromegrass pasture. In other words the crested-wheatgrass pasture was worth more per acre for milk production.

While 3.17 acres of bromegrass pasture were required as compared with 2.7 acres of sweetclover pasture, the returns per acre were slightly larger for the bromegrass. This may have been because of the bitterness of the sweetclover in 1924 and 1925, which caused it to be unpalatable. This bitterness was probably caused by the extremely dry seasons of those years. After growth has ceased the sweetclover pasture for this particular region cannot be cured on the ground for future pasturing as native grasses are cured. As soon as the sweetclover matures, the leaves shatter and fall off.

Native pasture grass was lowest in value per acre and also required the greatest acreage per cow for 112 days of pasture season. One point, however, in favor of the native-grass pasture is that the stand can probably be maintained indefinitely. It is difficult to obtain stands of the cultivated pastures, and it is not known how long the stands can be maintained without reseeding. It has already been necessary to reseed the sweetclover pasture once, and the stand in 1925 was not satisfactory.

TABLE 26 -- Results of pasture experiments with dairy cows at the Ardmore station for the four years 1922 to 1925, inclusive.

Season and Kind of Pasture	Pasture Area	Pasture Season: Dates1/	Pasture Season: Length	Cow-days per acre	Land needed per cow per season2/	Milk Produced per acre: Total	Milk Produced per acre: Per cow-day	Feed per Cow-day: Grain	Feed per Cow-day: Pasture equiv.: Silage	Feed per Cow-day: Pasture equiv.: Alfalfa Hay	Value of pasture per season per acre 3/
	Acres		Days		Acres	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Dolls.
Season of 1922											
Native	15	May 15-Sept. 30	139	27.8	4.0	721.8	26.0	5.70	34	14	4.63
Season of 1923											
Native	5	May 16-Sept. 5	113	34.0	3.3	983.6	28.9	5.56	36	15.5	6.09
Sweetclover	5	June 28-Sept. 5	70	54.6	2.1	1,371.3	25.1	6.23	30	14	8.38
Crested Wheat-grass	5	May 4-Sept. 5	125	61.4	1.8	1,692.8	27.6	3.85	40	16	11.91
Bromegrass	5	May 7-Sept. 5	122	54.2	2.1	1,408.6	26.0	3.88	36	15.5	9.70
Season of 1924											
Native	5	May 15-June 25	42	16.8	6.7	466.9	27.8	5.75	35	15	2.92
Sweetclover	5	---do---	42	41.4	2.7	1,071.1	25.9	6.39	32	14	6.63
Crested Wheat-grass	5	April 28-June 25	59	31.2	3.6	1,017.3	32.6	7.18	30	17	5.16
Bromegrass	5	May 1-June 25	56	26.6	4.2	919.2	34.6	6.84	35	18	4.95
Season of 1925											
Native	5	April 30-July 15	77	29.6	3.8	4/375.9	12.7	4.10	30	10	4.07
Sweetclover	2.5	June 25-July 8	14	33.6	3.3	4/650.7	19.4	4.65	30	12	4.89
Crested Wheat-grass	5	April 27-July 15	80	40.6	2.8	4/506.4	12.5	2.47	34	9.5	6.03
Bromegrass	5	April 27-July 8	73	35.2	3.2	4/681.0	19.3	3.00	33	13	5.61

1/ Both dates inclusive.
2/ Based on 112 days, the average reported for the herd.
3/ Value of pasture was calculated from the value of the silage at $6.50 a ton and the alfalfa at $8 a ton.
4/ Not all of the cows used in pasture experiments in 1925 were in milk, which accounts for the low production per acre.

TABLE 27 -- Summary of the acreage required to pasture a cow for a season of 112 days at the Ardmore station.

Year	Native grass		Sweetclover		Crested Wheatgrass		Bromegrass	
	Land needed per cow	Value per acre	Land needed per cow	Value per acre	Land needed per cow	Value per acre	Land needed per cow	Value per acre
	Acres	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars
1922	4.0	4.63	---	---	---	---	---	---
1923	3.3	6.09	2.1	8.38	1.8	11.91	2.1	9.70
1924	6.7	2.92	2.7	6.63	3.6	5.16	4.2	4.95
1925	3.8	4.07	3.3	4.89	2.8	6.03	3.2	5.61
Average	4.45	4.43	2.70	6.63	2.73	7.70	3.17	6.75

If satisfactory stands of crested wheatgrass and of bromegrass can be maintained over a period of years, it would appear from the results obtained thus far that these two grasses offer more profitable pasturage than the native grass. However, the cost of preparing the ground for these pastures, the cost of the seed, and the duration of the stand must be taken into account when comparing such pastures with the native ones.

As has been said, it is the custom in this vicinity to allow enough acreage per cow so that during the best growing months some of the grass will cure on the ground, where it will be available for pasturage after growth has ceased. In Table 26 in the column "Land needed per cow per season" the acreage required per cow is calculated to a basis of 112 days for the pasture season, since this was the average for the herd at Ardmore for the four years 1922 to 1925, inclusive.

For example, the pasture season for native grass in 1924 was 42 days, and an acre furnished pasture for 16.8 cow-days; therefore it is presumed that 6.7 acres would have been required to provide pasturage for 112 days. In addition to this pasturage the cows in every case were fed grain. The relative effect on milk production of the grass consumed during the growing season and of that allowed to cure on the ground is not known, however.

Season of 1922.--In 1922 no attempt was made to pasture the grass as fast as it grew, but the practice usual in this section of allowing a part of the grass to cure standing was followed. By this practice pasturage is provided for the entire season if sufficient acreage per cow is allowed. Normal rainfall in May, June, and July was followed by extremely dry weather in August and September. In May and June an overabundance of grass was produced; in July the grass grew about as fast as it was consumed; and in the latter part of August and during September the growth was practically at a standstill, the grazing then consisting largely of the standing cured grasses.

Season of 1923.--The pasture season of 1923 was preceded by heavy precipitation in November 1922, and considerable snow during the winter season. March and April were comparatively cool.

In the native-grass pasture the western wheatgrass started April 10, the grama grass April 20, and the buffalograss May 1. Pasturing began May 16. As in 1922, the overabundant grass in May and June cured standing and was eaten in late July and early August. A good rainfall then produced a new growth of grass, making pasturing possible from August 23 to September 5.

The sweetclover pasture, having a poor stand, was reseeded in the spring, and pasturing on the new growth started June 28. When first placed on the sweetclover pasture the cows trimmed up the native grass along the fence rows and then started in on the sweet clover, always eating the tenderest portions first.

The crested-wheatgrass pasture was the earliest growing of the four used in the experiment, and pasturing began May 4. The grass grew in clumps, and when it was pastured the cows ate the tops of the growing stems. The stems then continued to grow, became round, hollow, and jointed, and were not so palatable as the top growth. During July, because of hot weather and a lack of moisture, the growth was greatly reduced, but rain in early August made pasturing possible from late August to September 5,

The bromegrass was later in starting than was the crested wheatgrass, and growth was slow until after May 1, but by May 7, when pasturing began, the grass was 5 inches high. This grass seems to thrive best and to produce the most pasturage in the presence of a combination of warm weather and moist soil. The bromegrass pasture suffered in July because of lack of moisture and hot weather, but revived with the early August rains and was pastured to September 5.

Season of 1924.--The pastures in 1924 suffered from lack of moisture. While the precipitation of the previous fall and winter was about normal, that of April, May, June, and August was below normal.

The native-grass pasture was slow in growing, and the grass was eaten as fast as it grew, the buffalograss and grama grass never growing high enough to provide any appreciable quantity of pasturage.

The sweetclover pasture had a thick stand of second-year plants, but they grew slowly and were very bitter and therefore not palatable. The seeding plants produced no pasturage.

The crested wheatgrass pasture made considerable early growth, but there was not sufficient moisture and cool weather to keep the grass growing, and the grazing capacity dropped to the level of the other pastures.

The bromegrass started April 5, and pasturing began May 1. Growth was slow, and the rainfall was never sufficient to allow the pasture to make a good showing.

Season of 1925.--The season of 1924 was subnormal in regard to rainfall, and the spring of 1925 was dry, warm, and windy.

In the native pasture the western wheatgrass began to grow March 1 and the buffalograss and grama grass April 10. Pasturing started April 30, and although the growth was earlier than usual dry weather and soil conditions combined made growth slow. The grass seemed unpalatable and tough, and the cows therefore consumed a slightly smaller quantity per day than in 1924, even though there was more grass.

The sweetclover pasture, because of the lack of rainfall in 1924, was so dry that none of the seedling plants had developed sufficiently to withstand the winter; in fact, many had died before winter set in. Seedling plants of 1925 provided the only pasture that was obtained during the season. They grew slowly, because of dry weather and soil. Weeds got a good start, and it was not until after the rains of June 3 to 9 that the sweetclover was able to crowd them out. There was very little growth after the cows were placed on the pasture June 25, because of the dry weather.

The crested wheatgrass grew slowly, and pasturing began April 27. The dry weather of early May caused a curling of the grass leaves and gave the field a dead, dull-green appearance. With the rains of May 15 and 16 the grass improved and continued to grow until July 15, by which date all the pasturage was consumed.

The bromegrass pasture suffered from the dry weather and was pastured only from April 27 to July 8.

GENERAL PASTURE OBSERVATIONS

Climatic rather than soil conditions are the limiting factors in the production of pasturage. Native grasses as well as those not indigenous to this section are affected by these limiting factors. All vegetation dries up when sufficient moisture does not enter the soil to keep up growth. Native grasses do not produce as much pasturage during May and June as do the cultivated plants with which experiments have been carried on. The average rainfall at the Ardmore station for a period of 13 years shows progressively smaller precipitation each month after June during the growing season. The cool or moderate temperatures during April, May, and June make a given quantity of moisture more effective for grass production than a like quantity would be in July, August, and September, when higher temperatures are recorded and there is consequently a higher surface evaporation. Therefore, unless a rainfall much heavier than normal occurs in these three latter months, there can be no growth of pasturage.

In 1923 it was possible to pasture cows until July 25, because of the rainfall in May and June, which was above normal, although that in July was below normal. In August the rainfall was more than double the average, and a limited amount of pasturage was obtained in the fall.

In 1924 rainfall during April, May, and June was below normal, and a much smaller quantity of pasturage was obtained during these months. In July 1924, rainfall was a little above normal. All the pastures started growth, but they did not grow sufficiently to produce any pasturage.

In 1925 rainfall during April and May was below normal, that in June a little above normal, that in July slightly above normal, and that in August and September below normal. The excess of June moisture made possible some pasturage in July.

If midsummer and late-summer pastures is desired, it can be obtained only by one of the two following methods. Even with these there is no certainty of obtaining the pasturage.

(1) Allowing native-grass pastures (and possibly some of the cultivated grasses) to grow and come to their full development without pasturing, and then turning the livestock into the cured standing grasses during the midsummer and late-summer period.

(2) Planting annual cultivated crops suitable for pasturing, such as Sudangrass, either on fall-plowed or early spring-plowed land at such a time that they will be ready for pasturing at the beginning of the midsummer season. For best results with such pastures in this section, fall plowing is preferable to spring plowing, with the necessary disking or harrowing for clean cultivation until seeding time.

Sudangrass was seeded for pasture in 1925, and, although not enough data are yet available for comparative purposes, in that year it produced green and palatable succulent feed during midsummer when other pastures were poor and not so palatable. The number of days of pasture from the Sudangrass was very nearly equal to the number from the best-cultivated perennial pastures, but the number of days of pasture from the cured standing native grasses was less than half that from these native grasses when pastured while growing and green.

Although it is sometimes very difficult to obtain a stand of the cultivated grasses, the maintaining of such a stand is not a difficult matter, at least as far as limited experience goes. Both the crested wheatgrass and the bromegrass pastures had better stands at the close of the 1925 season than ever before. In the case of the crested wheatgrass, the thickened stand was obtained by the grass clumps becoming larger and larger. In the case of bromegrass, underground runners sent up shoots, producing vegetation in spots that were noticeably bare during the first and second seasons of growth. The maintaining

of a stand of sweetclover pasture is a difficult matter, owing to the fact that it is continually necessary for this plant to reseed itself.

Experience shows that both bromegrass and crested wheatgrass will stand very unfavorable climatic conditions, such as dry summers and open winters. They are well adapted to this section in that they are not easily killed out by such conditions. Sweetclover , on the other hand, not being a perennial, presents a different problem. It is possible to obtain an excellent stand of sweetclover if sufficient moisture is available at sprouting time, and then the entire stand may be summer-killed by droughty conditions later on. If the seedling sweetclover lives through a dry summer, it is likely to have an underdeveloped root system and a lowered vitality that will render it liable to winter-killing.

Cotton, J. S. 1905. Range Management in the State of Washington. Bur. Plant Indus., USDA, Bulletin #75, 26 pages, illus.

Owing to the greatly lowered carrying capacity of ranges in the State of Washington, investigations were begun in the spring of 1901 to determine, if possible, what steps must be taken to preserve these ranges and what methods should be used to bring the badly overgrazed areas back to their original state of productivity. These investigations were carried on cooperatively between the Bureau of Plant Industry of the United States Department of Agriculture and the Washington Agricultural Experiment Station from that time until January 1, 1904, when the experiment station withdrew. Since that time these investigations have been carried on independently by the Bureau of Plant Industry.

In the early nineties the ranges were very much overgrazed, and owing to the overcrowded conditions, were deteriorating very rapidly.

The only time of year when special care will need to be exercised in the grazing of these pastures will be in the spring months, when the young plants begin to grow. If the land be too heavily grazed at that period the young plants will be entirely killed out. This trouble can, however, be easily remedied by dividing the grazing area into two or three pastures, and by grazing off that portion of the land which is to be allowed to restore itself during the winter and excluding the stock during the time the young plants are getting a start. The next year another field can be given a like chance, and so on, alternately. In this manner it would be only a few years - probably not more than seven or eight - before the so-called desert areas would be restored to their original carrying capacity before overgrazing took place. Meantime the stockman would have full use of his land, and would be able gradually to increase the number of stock grazing on it, provided he judiciously confined the aggregate of his stock to the limit of the carrying capacity of his range.

So far emphasis has been put on the fact that fencing is the main secret of range improvement. Yet fencing is absolutely of no value unless the stockman will treat his pasture with just as much care as he would his wheat field. Fencing is merely a means to an end.

Many of the stockmen, especially cattlemen, seem to think that when they have excluded the outside stock, sheep in particular, from their land, it will carry whatever stock they may have; and they are disappointed if it does not. While it is true that some kinds of stock do more damage to a given range than others, the injury is caused not so much by the kind as it is by the number of stock and the methods used in handling it. Just because the stockman has fenced his range and excluded all outside stock he must not lose sight of the fact that he has not in the least changed the carrying capacity of his range.

In many parts of the State of Washington the ranges would be greatly benefited if the owner instead of having one large pasture would subdivide it into a number of small ones, so that once in three or four years each pasture would have a chance to rest and reseed itself. This would not mean that the owner would be deprived of the feed from that field, but simply that he would let the field lie idle for a couple of months during the time of going to seed, and use the dry feed later in the season. It would probably be necessary to protect this field from heavy grazing long enough in the following spring to give the young plants a chance to become so well established that the stock would not pull them up.

One of the most serious damages to the range is caused by turning the stock upon it too early in the season. A great deal of the injury that has been done by sheep is due to this cause. Their owners, in order to get ahead of others, have pushed the sheep out on to the bunchgrass land while the ground was still soft and "punchy." In this manner the ground became badly packed and many young plants were destroyed almost before they had begun to grow, while much of the prevailing vegetation was greatly retarded in its growth by being nipped too early in the season. This same process was kept up as they followed the retreating snow up into the high mountains. Numerous instances have been observed where sheep have been run over the mountain ranges even before the frost was out of the ground.

When the stockman once gets his range under his control, he should endeavor to avoid too early grazing. He will find that in the long run it will be better to hold the stock from this area until the ground has become settled and the vegetation has had a good start. If it is impossible to do this, he should endeavor to confine the damage to as small an area as possible.

Cotton, J. S.. 1907. The Improvement of Mountain Meadows. Bureau of Plant Industry Bulletin No. 117, 29 pp., illus.

For a number of years the Bureau of Plant Industry has been carrying on investigations to determine what can be done to improve the stock ranges that have become badly depleted through overgrazing. In this work considerable attention has been paid to the grazing conditions in the mountains where the problem of summer pasturage is of very great importance in the production of beef and mutton.

A careful study of the conditions involved in these areas has led to two general conclusions: (1) On the mountain ridges, where the soil is usually very shallow and close to bed rock and is of a more or less sterile nature, very little can be accomplished in the way of range improvement. While reseeding may sometimes prove practicable, such improvement must ordinarily come through careful protection from overgrazing in order that the original vegetation may be given a chance to restore itself. (2) In the mountain meadows and park-like areas, where there is ordinarily a good, rich, loamy soil, there are very great opportunities to increase the quantity of feed produced, and this increased production can very largely be secured by reseeding.

In connection with these investigations a range experiment station was established in the Wenache Mountains in Washington State in the fall of 1902, at which time seeding experiments were begun. These experiments were carried on cooperatively by the Washington Agricultural Experiment Station and the Bureau of Plant Industry. The following year other experiments were undertaken in the Sierra Nevada Mountains, California, the latter being under the direct charge of Mr. Charles H. Shinn, Supervisor of the northern district of the Sierra National Forest. In 1906 further experiments were begun in the Warner Mountains in northeastern California, under the care of Forest Supervisor A. H. Hogue. In addition to these experiments numerous observations have been made on the results obtained by stockmen in various parts of the country in their efforts to improve the mountain grazing areas.

The Wenache Mountain Station is located on the summit of the mountains, some 26 miles northeast of Ellensburg, and is at an altitude of a little more than 5,300 feet. It is highly typical of the entire mountain region along the eastern slopes of the Cascades in Washington. Practically all the different soil and climatic conditions found in this region are represented at the station or within a very few miles of it. The annual precipitation is probably not far from 20 inches and comes largely in the form of snow. The growing season does not much exceed four and a half months. The snow goes off some time between May 20 and June 1. The ground is usually frozen by the middle of October and snow falls to stay soon after November 1.

The station lies in the general course traveled over in the spring by the numerous migratory bands of sheep in going from the desert or low-land ranges to the high mountain pastures in the Cascades, and again in September on their return to the lowlands. As a result the region had been severely overgrazed for a number of years and the vegetation was in a badly depleted condition, much of it having been completely exterminated.

The station comprised a section of land that Babcock & Benson, the owners of a large sheep and cattle range, had inclosed with a good stock-proof fence as a holding pasture for their saddle and pack horses. As the problem of increasing the quantity of feed in the high mountain meadows was one of great importance to them, they donated the use of this section for experimental purposes. These men endeavored to keep out all stock from this area during those periods of the year when grazing might injure the grasses in the various plots, and in other ways did all they could to make the work successful.

The experiments of the Bureau of Plant Industry show quite conclusively that the depleted mountain meadows can be brought back to their original carrying capacity in two to three years' time by reseeding with tame grasses. There are numerous instances, notably in the Cascade Mountains of Washington, where by the introduction of such grasses the meadows can be made to produce more forage than they ever did.

Out of the thirty or more grasses and forage plants tested, there are seven -- tall fescue, orchardgrass, bromegrass, mountain bromegrass, slender wheatgrass, timothy, and redtop -- that have shown themselves to be of some importance in the restoration of mountain grazing areas. Timothy and redtop have proved to be of great value for this purpose. These two grasses can be introduced at a comparatively small cost, will furnish satisfactory yields, and will readily withstand moderately heavy grazing.

Craddock, G. W., and C. L. Forsling. 1938. The Influence of Climate and Grazing on Spring-Fall Sheep Range in Southern Idaho. USDA, Tech. Bull. No. 600, 43 pages, illus.

The United States Sheep Experiment Station, located near the northeastern extremity of the Snake River plains of southern Idaho at an elevation ranging from 5,500 to 6,000 feet, covers 28,160 acres, of which 16,640 acres was under fence during the study.

Temperatures are generally favorable for plant growth from early April until late October. Precipitation rarely exceeds 15 inches annually. Somewhat less than half of the precipitation occurs as snow during the late fall and winter; rains are most common in spring and summer. During late spring, and especially through the summer months, rainless periods are common, during which the soil becomes thoroughly dried for weeks at a time.

In response to the climate and soil, the vegetation on the station range is an unbroken gray-brush formation covering about 25 percent of the ground surface, in which big sagebrush (*Artemisia tridentata*), or a closely related threetip sagebrush (*A. tripartita*), and bluebunch wheatgrass (*Agropyron spicatum*) are dominant. Shrubs constitute more than half of the plant cover, but grasses and weeds make up 86 percent (58 and 28 percent, respectively) of the palatable part of the vegetation, of which slightly more than 61 percent is contributed by three species--bluebunch wheatgrass, bluegrass (*Poa secunda*), and balsamroot (*Balsamorhiza sagittata*).

On these five, 80 acre paddocks intensive use of the forage was instituted during the years 1924 to 1932, inclusive, approximating the systems of use commonly applied in private operations on comparable rangelands in the vicinity of the station. A different system was applied to each paddock. These may be explained briefly as follows:

A. Heavy continuous spring and late fall grazing (paddock 2). In this paddock an average of about 68 percent of the forage was removed during approximately a 2-month period in the spring after grasses reached 2 inches in height; 25 percent was taken in the fall, making a total of 93 percent for the year. This system is representative of practices on extensive range areas where one or several bands of sheep graze more or less continuously throughout the spring period and utilize nearly all of the forage at that time, only to return and regraze the area in the fall.

B. Heavy early spring and late fall grazing (paddock 3). On this area an average of about 36 percent of the forage was taken during approximately a 4-week period in the spring commencing after grasses reached 2-inch height growth, and about 46 percent was removed in the fall. This system is typical of use on areas where sheep are turned out to graze about the same time each spring, but, because of available range elsewhere, the lack of water, or other reasons, the use is limited to an early, short period in the spring, followed by more complete utilization in the fall.

C. Heavy late spring and late fall grazing (paddock 8). This pasture was grazed each year so as to utilize about 53 percent of the forage in the spring within the average of approximately a 3-week period after grasses reached a 6-inch height growth, and 37 percent in the fall. This arrangement corresponds to situations where sheep reach the range and consume about half of the current growth after the forage has attained advanced stages of development and where the same range is subjected to close fall grazing.

D. Moderate late spring and heavy fall grazing (paddock 7). Grazing on this area removed, during approximately 3 weeks in the spring, an average of 19 percent of the forage after grasses reached 6-inch height growth, while in the fall 66 percent was removed. This system differs from that followed on paddock 8, in that spring grazing was confined to a shorter period and was less heavy. It is characteristic of the manner in which some ranges are grazed rather lightly in the spring, after which they are heavily utilized in the fall.

E. Heavy fall grazing only (paddock 1). As check on the other systems, this paddock was grazed only late in the fall, forage consumption averaging approximately 83 percent.

The paddocks were grazed in the spring by ewes and young lambs, while in the fall only mature ewes were admitted, except for a few rams during part of the time for breeding. The numbers usually grazed in each area from day to day varied from 30 to 40 head, although for a few days at a time it was found necessary to decrease the numbers to 10 or less when sheep were not available, or to increase the numbers to 100 or more in order to "mop up" remaining "feed."

Serious range depletion occurred on four 80-acre range areas where for 9 years from 19 to 68 percent of the available forage was utilized in the spring followed by the removal of from 25 to 66 percent of the forage in the fall, or a total for the year of 82 to 93 percent. The degree of depletion on the four ranges was approximately directly proportional to the intensity of spring use. Measurable effects of overgrazing included the reduction of from 20 to 65 percent in grazing value, an increase of 27 to 73 percent in the density of relatively unpalatable sagebrush and other shrubs, a decrease of 14 to 81 percent in the density of highly palatable weeds and bunchgrasses, and a delay of as many as 14 days in the occurrence of 2-inch height growth of grasses and diminished weed-flower production due to decreased vigor.

On another 80-acre range area on which, on the average, 83 percent of all available forage was utilized in the fall and none in the spring, the range definitely improved. This improvement was characterized by an increase of 15 percent in grazing value, a 15- and 16-percent increase in the density of grass and weed forage, respectively, and a 5-percent decrease in the density of sagebrush and other shrubs.

The herded portion of the station range was maintained in a productive condition when grazed according to a rotation system whereby in average years approximately 30 to 35 percent of the available bunchgrasses were utilized in the spring, starting when the grasses approached 2-inch height growth; and about 33 percent in the fall, or up to 65 percent for the year as a whole. For the 9-year period this range was used at the rate of about 1½ acres per sheep per month, for approximately 2½ months in the spring and in the fall.

From these results the following conclusions are drawn with respect to proper periods of range use, the rate of stocking, and systems of grazing for range sheep management on spring-fall ranges in southern Idaho characterized by sagebrush-bunchgrass vegetation.

1. The yearly calendar of operations should be planned so as to begin spring grazing after grasses reach 2-inch height growth. There is a minimum of variation in this stage of development, thus insuring available forage in most years and necessitating the maintenance of not more than a 10-day supply of reserve feed for the exceptional year when forage development is late. This also precludes misuse of the range; since, from this time on, forage growth will ordinarily progress in advance of the sheep, insuring that adequate feed will be available during the entire spring season if the range is not overstocked. Near Dubois, Idaho, 2-inch height growth is reached on the approximate average date of April 22. Spring grazing should end when bunchgrasses begin to cure, which occurs about July 2 near Dubois.

2. Fall grazing should begin when summer range is utilized, but preferably after rains start regrowth of grasses or soften the cured bunchgrasses. Since fall grazing must end with the coming of deep snow and this occurrence is extremely variable, a 30-day reserve supply of feed or its equivalent of protected winter range over and above normal winter requirements should be maintained as insurance against years of early snows.

3. For ranges having a total plant cover of about 25 percent, comprising approximately 45 percent of bunchgrasses and palatable weeds and 55 percent of sagebrush and other less palatable shrubs, stocking should be at the rate of two-thirds of a sheep per acre per month for approximately 2½ months in the spring and in the fall. A lower rate of stocking is recommended where relatively less bunchgrass and weed forage is available, and a higher rate on areas supporting a more dense stand of palatable vegetation.

4. Rotation spring grazing is essential for maintaining sagebrush-bunchgrass range under the conditions of climate which prevail in this section. This system can be applied by dividing the range into two or more convenient units and routing the sheep from one to the other as the season advances, beginning this process with a different unit each succeeding year. The periods of use and rate of stocking should be adjusted so that approximately one-third of the available bunchgrasses over the range as a whole are utilized during the spring season after grasses reach

2-inch height growth, and not to exceed two-thirds of the total in the fall of average growth years. This system of management will insure adequate forage in the poorest growth year and in good years will permit range plants which may have been heavily grazed in previous years of drought to recover vigor. Moreover, because ample forage is available under this system, the sheep can be expected to be maintained in a thrifty and productive condition.

5. Deferring all grazing until fall for a period of several years on successive portions of the range is recommended for obtaining maximum improvement of depleted range.

Dickson, R. E., C. E. Fisher, and P. T. Marion. 1948. Summer Grazing Experiments on Native Grassland at Spur, 1942-1947. Tex. Agr. Exp. Sta. Prog. Rept. 1123. pp 8.

The principal native grasses are buffalo and tobosa with smaller amounts of vine mesquite, purple threeawn (needle grass), sideoats grama and trace amounts of many others. The soils are largely clay loams of the Abilene, Tillman, Weymouth and Spur series and generally are considered fertile but drouthy. The topography for the most part is smooth to gently sloping with some comparatively level areas that are occasionally flooded. There are a few gravelly knolls along the ridge lands where the soil is shallow and the vegetative cover is thin.

Rainfall for the 6-year period has been approximately one inch below the 36-year average (20.71").

Yearling steers averaging 450 to 550 pounds are used in native pasture studies. Prior to summer grazing these steers are used in wintering experiments, and upon completion of summer grazing experiments they are used in feedlots for fattening studies.

The date of beginning and completing experimental grazing tests varies with seasonal conditions. Every effort is made to utilize the grasses at their most nutritious stage during the spring and summer months. The length of the grazing season has varied from 91 to 196 days depending on seasonal growth of grass.

Two rates of utilizing forage have been used in these studies. Heavy grazing consists of rather complete use of all forage or 75 percent of growth throughout the summer grazing season. Light grazing consists of stocking to give some choice of forage and 50 percent use of growth for the season. For the 6-year period, 6 light grazed pastures have been stocked at an average rate of 1 steer to 5.01 acres while 6 heavy grazed pastures have been stocked with 1 steer to 3.40 acres.

Utilization of more than 50 percent of the forage on these pastures, or stocking 50 percent heavier to utilize an average of 75 percent of the forage with yearling steers, reduced the average summer gain per acre from 29 to 27 pounds and decreased the gain per steer by 55 pounds.

Studies made in 1947 to determine changes in total vegetative cover since 1942 show that light grazed pastures have 30 percent more cover than heavy grazed pastures. They also show that tobosa, purple threeawn, vine mesquite, and little "muhly," which are usually less desirable grasses, were decreasing on light grazed pastures when compared with the heavy grazed pastures.

The light grazed pastures were stocked at the rate of 47 yearling steers per section on a year-round basis and the heavy grazed pastures at the rate of 75 head per section. If the good seasons, 1942 and 1943 are used as a base, then productivity dropped 39 percent in the last 4 seasons on light grazed pastures and 63 percent in heavy grazed pastures.

The steers, in utilizing 50 percent of the current year's growth took practically all of the choice forage while those on heavy grazed pastures utilized much grass that had very little feed value.

Upon completion of 6 years of grazing with yearling steers, it appears that the pastures that were to be light grazed actually were grazed moderate to moderately heavy, while the heavy grazed pastures in nearly all instances have reached an overgrazed condition.

This study consists of using the forage rather heavily on a pasture for one month and then resting the pasture for two months. Three pastures are used in this rotation and they are compared with two pastures grazed continuously.

Summary of rotation and continuous grazing treatments, 1942-47

No. of pastures	Grazing treatment	Acres per head	Grazing season days	Ave. annual gain, pounds			Utilization of forage, percent
				Acre	Daily	Steer	
3	Rotation	5.29	146	24	.87	129	53
2	Continuous	5.11	146	26	.91	134	53

There has been no advantage for pastures grazed in rotation over those used continuously when the same rate of stocking for the season is used.

Dillon, Claude C. 1958. Benefits of rotation-deferred grazing on northwest ranges. Jour. of Range Mgt. 11(4):278-281. illus.

Dale Bly, a breeder of registered Aberdeen Angus cattle near Harrington, Washington, has been practicing a rotation-deferred system of grazing on his 840-acre ranch since 1950.

The grazing program prior to 1950, consisted of dividing the cattle into two herds, and turning each herd into a pasture, where they remained for the grazing season (April 1 to November 15), with the exception of a month from August 15 to September 15 when all the cattle were turned onto wheat stubble. Two pastures weren't enough to do a good job of animal husbandry on the range and Bly felt that his range was going downhill instead of improving.

The ranch lies in a 12-14 inch precipitation belt. Approximately two-thirds of the annual moisture falls in the form of snow during the winter and early spring months. May and June rains contribute to the annual grass production. The summer months are usually dry and warm. Fall rains do occur, but cannot be depended upon every year in sufficient amounts early enough for good fall regrowth. The elevation is approximately 2,200 feet.

The ranch was cross fenced along 5 distinct soil-vegetative types which varied from saline soils to deep loam to shallow strong soils. Predominant grass species were bearded wheatgrass, Sandberg bluegrass and Idaho fescue.

A rotation-deferred system of grazing was inaugurated to allow one pasture to rest until seed maturity each year. The sequence of grazing was varied each season, so as not to graze the same pasture at the same time each year.

The benefits of this system of grazing on this ranch may be summarized as follows:

1. The system corrected a bad distribution problem.

2. It has been possible to get improvement over all the ranch, even though the key grasses have a different season of use.

3. An even utilization of practically all forage.

4. A 100 percent increase in carrying capacity.

5. The quality of the forage improved which was reflected in heavier calves.

Dillon, Claude C., and Daniel Wallenmeyer. 1966. A Rancher's Success with Continuous Deferred Grazing in Washington State. Journal of Range Management, 19(6): 380-382, illus.

Current results of range management on ranches in low rainfall areas (7 to 15 inches) of eastern Washington indicate that deferred grazing or very light grazing during the spring green growth period is important to improvement of bluebunch wheatgrass (Agropyron spicatum) rangelands.

Ralph Snyder, cattle rancher near Benge, Washington, by improving range condition since 1955 has more than doubled the forage yields on his ranges. His ranch, located along Cow Creek in southeastern Washington, consists of 6500 acres of rangeland, with an additional 225 acres of irrigated pasture. Alfalfa hay, used to supplement range in winter, is raised on an irrigated unit in the Columbia Basin. The basic cattle herd consists of 410 brood cows, 13 bulls, and 200 yearlings. Cattle numbers are varied seasonally to meet differences in range forage production.

The annual precipitation at the Snyder ranch is 10 to 15 inches with about two-thirds falling during the winter months. Temperatures range from as low as -15°F. to 100°F. Summers are usually hot and dry. The main growth period for the range grasses is from mid-April to mid-June.

The rangelands on the ranch are composed of channeled scablands and open bunchgrass plains. The scablands contain small "pothole" like alkali meadows. Bluebunch wheatgrass, basin wildrye (Elymus cinereus), and inland saltgrass (Distichlis stricta) are the primary forage plants in these meadows. The open bunchgrass plains produce bluebunch wheatgrass with an understory of Sandberg bluegrass (Poa secunda).

Snyder uses these ranges primarily for fall and early winter grazing; summer grazing is limited mainly to the saltgrass of the alkali sites. Cattle are usually kept off the ranges from February through June. They are fed alfalfa hay during winter and early spring until the irrigated pasture is ready the first part of May. Alfalfa hay is also used to supplement range for weaner calves when grasses are dry. Snyder says that shortening the winter feeding period with improvement of bluebunch wheatgrass has enabled him to graze cattle during December and January.

Snyder received a range site and condition survey and conservation planning assistance from the Soil Conservation Service in 1955. A new survey in 1965 showed that most of the poor condition range had improved to fair; the fair condition range of 1955 had improved to good, and in some places excellent, condition.

The cattle stocking rate totaled 1,000 cow months of grazing from rangeland in 1955; this had increased to 2,310 cow months of grazing in 1965. During this period, if a pasture had to be grazed during June, it was only lightly grazed and was deferred from grazing the next spring. The range management Snyder has been practicing during the past 10 years is summed up in his own words: "We try not to use the grass too close....When we quit grazing our bunchgrass during May and June, it really started to come." His statement refers to two basic practices as understood by range technicians - proper range use and deferred grazing.

The increase in stocking rate, concurrent with striking improvements in range condition is evidence that bluebunch wheatgrass can make rapid improvement with deferred or light spring grazing. Indications are that refraining from spring grazing entirely in dry years may be the best way to improve bluebunch wheatgrass ranges in this area.

The growing season is short for bluebunch wheatgrass in climates like that of the Snyder upland range. Lack of moisture is the dominant limiting factor of growth. Temperatures are not warm enough for much growth before May 1, and the moisture usually runs out by the middle of June. It could very well be that low-vigor bluebunch wheatgrass needs all of its leaves in order to improve, especially when the stand has been invaded by cheatgrass.

We conclude that bluebunch wheatgrass ranges in low rainfall areas of eastern Washington will improve most rapidly when other pastures of feed are provided during May and June, and main growth period. We recommend that whenever possible, bluebunch wheatgrass in this area should be rested during the spring in years of low forage production, especially where stands are weak. Deferred grazing assures fast recovery for bluebunch wheatgrass ranges for soil and water conservation and improved forage production.

Douglas, L. H. 1915. Deferred and Rotation Grazing, Hayden National Forest, Wyoming. National Woolgrower, 5(10):11-14, illus.

The Hayden National Forest, in Wyoming, includes the summer range most easily accessible from the winter range of the Red Desert of Wyoming and other vast areas of winter range. The winter ranges have supported a greater number of sheep than the summer range on the forest would support, and as a result the summer range was badly overgrazed prior to the creation of the forest.

The area selected for the test is at an altitude of approximately 8,000 feet and is typical of a large area of sheep range on the western slope of the Sierra Madre Mountains, characterized by large park areas interspersed throughout areas of young aspen and young lodgepole pine forests. Some forage is found in the timber, especially in the aspen, but the large intervening park areas, or areas sparsely timbered, are the most valuable from a grazing standpoint. Originally the park areas were typically grass lands with a minor proportion of more or less valuable weeds, but due to continued overgrazing the most valuable species of both grasses and weeds were largely replaced by worthless weeds.

In June 1911, shortly after the beginning of the growing season, an area of 20 acres typical of the west slope range described, was selected for the experiment and fenced. In one corner an area of one acre was fenced off from the main tract, the object being to determine the rapidity of range recovery under total protection against grazing in the one acre area, the rapidity of recovery when grazed by sheep each year after seed maturity in the 19-acre area, and the rate of recovery under the customary season-long grazing on the unfenced range adjoining the fenced areas. All areas had been subject to the same grazing conditions prior to construction of the fence in June 1911, and the forage apparently was uniform as to density and species over all.

The actual measure, by charting and counting the number of plants and by measuring the tufts, showed that the 19-acre area, grazed after seed maturity in 1911 and 1912, had 100 percent more vegetation per unit area than the outside range which had been moderately grazed May 10 to September 15 each year, and 20 percent more vegetation than the one-acre area which had not been grazed at all from June 1911, to August 1913. Assuming that the unfenced area made no improvement after June 1911, it may be concluded that the total vegetation on the 19-acre area increased 100 percent and that the vegetation on the totally protected plot increased 60 percent from June 1911, to August 1913, three growing seasons. This conclusion is believed to be conservative for the reason that the unfenced range was not grazed as heavily during this period as it had been prior to 1911, and here as elsewhere on the Hayden Forest there was undoubtedly a slight increase in the amount of vegetation.

Measurements of many specimens of the same species showed that the seed stalks on plants from the totally protected area were approximately one-fourth longer than those of the same species on the area grazed after seed maturity and from two to four times as long as those of the same species on the adjoining range grazed seasonlong. The difference in number and size of leaf blades was in favor of the totally protected area but was less pronounced than the difference in length of seed stalks.

The foregoing tests substantiate facts brought out by tests elsewhere that there is little difference between the vigor of the plants after the second or third year of grazing after seed maturity only, and the vigor of the same species not grazed at all, but that there is a marked difference in the vigor of plants protected against grazing until after seed maturity, or totally protected against grazing, and the vigor of the same species, when grazed year after year during the growing season. This fact cannot be emphasized too strongly as it is becoming noticeable on ranges, considered properly stocked, where certain camps are grazed year after year before seed maturity. In such cases, on sheep range, the plants which sheep like best, and consequently graze first each year are gradually being weakened and are giving way in favor of plants which, while valuable as forage, are eaten as second choice and, therefore, have a better opportunity than the first choice plants of fulfilling their natural requirements of growth. That there is as much total vegetation, or even as much vegetation which stock will eat, this year as there was last year or five years ago does not mean that there has not been a change in the mutton producing value of the area. In the final analysis of range management and the final plans, this point will be one of first importance.

It is often held that the forage on areas where grazing has been deferred until after the plants have matured seeds will become dry and tough and, therefore, can not be used to advantage. On National Forest ranges heavy frosts usually come at about the time of seed maturity and as a consequence the succulent forage at best consists of the limited fall growth of perennial plants, primarily grasses. This being the case, it is believed that there is an advantage in having an area of untouched forage for this later period after heavy frosts set in. In the Hayden experiment, careful observations showed that after the sheep had picked out the small amount of tender weed foliage remaining when the 19-acre area was grazed after seed maturity, they ate the foliage and at least a portion of the ripened grain of the matured grasses, apparently with relish. The lambs may not hold their round, plump condition as well as where they have more succulent feed in abundance, but they harden on the dry forage and the grain in the native grasses and as a consequence are in the best condition for the drive to market or for the winter range. A light fall growth of green grass not infrequently is insufficient in amount for the sheep and results in their chasing about over the range and actually losing flesh. Unless there is enough green grass to satisfy them they will do better on the substantial air-cured forage and the grain they get from the native grasses.

In order to bring about the recovery of an overgrazed allotment it should be divided into 5, 4 or 3 parts, depending on whether one-fifth, one-fourth

or one-third of the grazing season remains after seed maturity. The division should be so made that the most severely overgrazed portion of the allotment will, if possible, be included in one division. This division should be protected the first year until the plants have matured seeds and it should then be heavily grazed, in order to aid in distributing and planting the seed. The second year on the same division the treatment should be the same, except the fall grazing should be moderate instead of heavy because of possible injury to young plants as a result of heavy grazing. If necessary for recovery, the same treatment should be given a third season. After recovery is satisfactory on the first division, the plan should be put into effect on each of the 5, 4, or 3 divisions of the allotment in turn.

Such a plan should be followed on all fully stocked or overstocked forests to bring about recovery of overgrazed allotments and on all forests to keep the range as a whole in a condition of maximum forage production.

Dyksterhuis, E. J. 1949. Deferred and Rotation Grazing. The Cattleman, 35(12):21, 60, illus.

There are several systems of grazing that provide rests for one or more pastures each year. If all the livestock are taken out of one pasture for certain months, the practice is called "deferred" grazing. It is called "rotation" grazing if in a year one herd of livestock is moved from pasture to pasture so that more than one pasture receives a rest or several rests all in the same year. If only two pastures are involved, this may be called alternate grazing. The most complicated system to plan is rotational deferment. This system takes more than one year. Under it different pastures are rested in successive years.

If we keep all livestock out of a tame pasture such as Bermudagrass and do not mow weeds, the pasture will be ruined in a few years. Just the opposite is true of natural pasture, that is, rangeland. Any land which was originally good range, such as the prairies and plains, will benefit from complete rests. Weeds may become quite numerous at first but this is a good sign on rangeland. It means that nature is getting the land ready for the grasses. The grasses that were there when the white man came will finally push the weeds out. But if too few good grasses are left in the pasture to seed the area in a reasonable time, it may pay to bring them in with seed-hay or seeding.

There is nothing more certain in range management than that complete rests improve poor ranges. Nature is constantly trying to reestablish the kind of vegetation each soil had originally. This is operation of the natural law of plant succession and the end product -- the original grasses -- is called climax. Several long rests usually result in better kinds of range plants. Short rests usually result only in better growth of kinds already there.

If certain pastures are rested, the stocking rate will be heavier on the other pastures. For example, if a man runs 100 head on two 1,000-acre pastures with the gate open between them, the stocking rate is 20 acres per head. If he closes the gate and keeps them all in one pasture half the time while the other pasture rests, the stocking rate is 10 acres per head.

Running twice as many on a pasture for half as long has advantages. It takes about half as much riding to look after the livestock. It gives part of the range a complete rest. It results in more even grazing because the livestock don't spend as much time traveling around hunting "ice cream" plants. Such plants are soon leveled and then livestock are forced to eat "meat and potatoes" too.

If the whole ranch is much overstocked, however, it will be impossible to spare even one pasture for a few months without running into poor gains or losses in weight.

Some Misunderstandings About Rests

Commonly we rest the poorest pasture first. Actually it is better to rest the best pasture first. It will respond sooner and with greater increase in forage production. The best pasture in top condition can carry a heavy load during the long periods of rest needed on the poor pastures.

Often a pasture is rested except for a few livestock. They are left in the deferred pasture because it makes a handy place to keep some horses, heifers, sick cows or rams. This practice has two effects: the parts of the pasture that need rest the most do not get it. Just a few head will keep areas near water and along draws grazed down. Also the very best grasses, the kinds that need rest the most, will be kept grazed down about as much with five head as with 50. Survivors of good grasses often are scattered over the pasture; but if they were all put in one place, they would not cover more than an acre or two in a section. A couple of livestock in a poor pasture make the rounds often enough to keep these most palatable grasses from increasing.

Tame pastures are often rotated at set intervals. For example, with two pastures an eight month season may be divided into four periods of two months each. In that way the livestock are on each pasture two months and off two months twice during the year. This works quite well on tame pastures such as Bermudagrass but has little value on range pastures. On ranges the periods of deferment must be aimed at increasing the amount of certain kinds of grasses. This means that the pasture must be rested during the months that certain key grasses make their growth and mature seeds, or during the months that they store food in their roots and rootstocks. The season of rest must be based on the needs of grasses rather than a certain number of months. Many of us have noticed that deferment of bluestem range for five months to September or October had little benefit in improving range condition because the livestock ate the heads before the seeds were mature. A deferment from June to frost would have met the needs of this grass. Pastures with different key grasses require different seasons of rest for improvement.

Another common misunderstanding about rests is that they should show immediate benefits in greater livestock gains.

Fisher, C. E., and P. T. Marion. 1951. Continuous and rotation grazing on Buffalo and tobosa grassland. Jour. Range Mgt. 4(1):48-51. illus.

Rotation grazing trials were undertaken at the Texas Agric. Exp. Sta., Spur, Texas, in 1942 to determine the value of using an intensive grazing period followed by a 2-month rest during the summer months to improve the productivity of native buffalo and tobosa grassland.

The vegetation consists primarily of buffalograss, tobosa grass, vine mesquite, and minor amounts of purple threeawn, sideoats grama, blue grama and trace amounts of other species.

Five ten-acre pastures were used for a comparison between rotation and continuous use.

Determinations were made of vegetal composition and basal density in April of 1942 and again in July of 1947. Observations of utilization were made at monthly intervals. Moisture penetration tests were made following torrential rains. Good quality Hereford yearling steers used in the study were weighed at monthly intervals.

The grazing season generally began May 1 and extended to October 1. The rotation and continuous grazed pastures were stocked at a moderate rate for the season to utilize 50 percent of available forage.

The system of rotation grazing consisted of grazing each pasture intensively for one month and resting it for two succeeding months. By use of a three pasture arrangement the same steers were used each month on a pasture which had not been grazed during the two previous months. On continuously grazed pastures the same steers remained on each pasture for the entire summer grazing period.

There was very little change in the vegetal composition of the more desirable forage plants and an increase of only 2.7 percent in basal cover on the rotation pastures. There was a marked increase from 54.8 to 73.0 percent in buffalograss and an increase of 6.5 percent in basal cover on the continuous grazed pastures from 1942-1947.

Utilization records of forage plants at monthly intervals over the 5-year period strongly suggested that rotational grazing in a fixed plan may well penalize buffalograss, sideoats grama and other species with a long period of palatability when growing in close association with tobosa grass that has a rather limited season of palatability.

In several instances, intensive use, coupled with a drought prior to a torrential rain, reduced the cover of the more palatable species on rotation grazed pastures well below that required for rapid absorption of rainfall. It is apparent that buffalograss suffered the greatest reduction in moisture penetration under rotation grazing.

An analysis of gains at monthly intervals during the grazing season indicates that a somewhat more uniform rate of gain by steers on continuously grazed pastures.

Fisser, H. G., M. May, W. M. Johnson, P. Stratton, and D. R. Smith. 1962. Comparison of Rotation and Season-long Summer Grazing on Subalpine Range In Wyoming--Progress Report--1961. Univ. of Wyoming, Wyo. Agric. Expt. Sta., Mimeo. Circ. #177, 3 pages.

The study of summer-long moderate stocking versus moderate and heavy rotation grazing rates was initiated in 1959 in the Bighorn National Forest. Included within each of the grazing systems were areas that, in the past, had been grazed lightly, moderately, and heavily. The 1961 season represented the third season of use under the deferred grazing program designed to evaluate the effects of a three-unit rotation system.

The summary of steer numbers and pasture systems is as follows:

	1959	1960	1961
Moderate, season-long (71 acres)	22	21	22
Moderate Rotation (256 acres)	73	74	73
Heavy Rotation (186 acres)	76	76	76

Steers within the rotation systems were placed on various pastures according to past use of grazing rates and rotated at monthly intervals in the three-month grazing system. The summary of rotation periods for the past three years as related to season-long past use is as follows:

Rotation Period	1959	1960	1961
Mid June - Mid July	Light	Medium	Heavy
Mid July - Mid August	Medium	Heavy	Light
Mid Aug. - Mid Sept.	Heavy	Light	Medium

The three year summary of animal gains, as related to treatments, is presented below:

		Moderate Season-Long	Moderate Rotation	Heavy Rotation
Pounds of gain per acre:	1959	44.21	50.11	61.46
	1960	53.66	57.00	67.71
	1961	51.83	47.90	57.47
Pounds of gain per animal per day:	1959	1.86	2.26	1.89
	1960	1.92	2.13	1.77
	1961	1.86	1.87	1.56

Percentage utilization of Idaho Fescue (the key management species) is listed below:

Treatment		Weighted Mean
Moderate--Season-long	1959	42.8
	1960	47.3
	1961	34.8
Moderate Rotation	1959	13.8
	1960	23.5
	1961	24.2
Heavy Rotation	1959	24.6
	1960	40.6
	1961	43.0

Forest Service, USDA. 1962. Rotation Grazing Management. USDA, Forest Service, Region 2, processed, 11 pages, illustrated.

The range resource on the Pole Mountain District is under heavy use pressure, not only from the permitted livestock but also from recreation users. There are 2,208 head of cattle and 4,800 head of sheep permitted to graze the 42,935 open, usable acres of range. The same general area was used by nearly one-quarter million recreationists.

Soil types are low productivity throughout the District. The soil is primarily decomposed granite and quite unstable. Annual precipitation averages 15 inches. Much of this moisture is lost due to desiccating winds. Forage production is therefore correspondingly low.

Topography of the District is characteristically rolling, broken by many small creeks and rolling ridges.

The ridges are generally dry and windswept. Cattle are prone to bypass these ridges and congregate in the sheltered and well-watered bottoms. Beaver have populated almost all live stream bottoms, making crossing of the streams difficult. These two factors increase the difficulty of proper management of the livestock on the range.

These physical problems, coupled with a general overstocking of the range, led to the establishment of two demonstration allotments on the District in 1958. Green Mountain was set up under a deferred-rotation plan of management and North Pasture Allotment under a rest-rotation plan of management. These programs were established cooperatively with the Laramie Unit of the Rocky Mountain Forest & Range Experiment Station. The purpose of the cooperative project was to utilize the best technical and administrative abilities of the two units. Technical data and study locations are under the supervision of the Rocky Mountain Forest & Range Experiment Station and management of the cattle and construction of the improvements are under the supervision of the Medicine Bow National Forest.

These two allotments have been operating under this type management for four grazing seasons.

In order to keep pace with the growing demand placed on these resources by public users; to attain a better degree of range livestock management; to fulfill our objective and policy of making this district a multiple use showcase or demonstration area, the remaining C&H allotments (Beacon and Horse Creek) have been placed under rotation management.

It is impossible, as yet, to begin any treatment of the Lodgepole C&H allotment since it is being used by Research as a check allotment on the Green Mountain and North Pasture studies.

The stocking rate was increased from 433 head of cattle to 877 head on North Pasture in 1962. Stocking was decreased from 714 head to 571 head on the Lodgepole allotment. The stocking rate on the Green Mountain allotment was not changed. The increase in stocking on the North Pasture allotment was based on utilization determinations. The overall condition and use of the Green Mountain allotment indicates that a 50% reduction is not necessary.

1. Preferred plant species are cropped once.

2. Desirable species are given a chance to establish vigor through storage of food and regrowth.

3. Seed production on desirable species is enhanced on three of the four pastures every year -- particularly the pasture grazed last or rested each year.

4. Utilization is more uniform over each unit than in open range grazing.

5. Seedling establishment and production is enhanced by rotation methods of grazing.

6. Indications are that calf crop percentages may be higher and calving season shorter.

7. Less desirable species receive some use under rotation grazing whereas light or no use was observed on these plants under season-long grazing.

8. Plant cover or density will be increased corresponding to the number of new seedlings that are established and watershed values will be enhanced.

9. This type of management permits deferment of areas infested with poisonous plants until plants are cured and safe to graze.

10. Less riding to obtain distribution is necessary which results in less trailing and trampling damage and favors weight gain for range cattle.

Forsling, C. L. 1927. Grazing Control is Needed for Proper Watershed Protection. USDA Yearbook, 1927, pp. 350-351.

On rough land, such as is ordinarily used for grazing, the herbaceous and shrubby plants that constitute forage for livestock help to check the movement of water on the sloping surfaces and to bind the soil against erosion. Grazing that destroys more or less of the plant cover not only reduces the capacity of the land to support livestock but may lead to damage by erosion and floods that is of far greater importance than the loss of the forage. The value of grasses and other low-growing plants for protecting watersheds may not be easily recognized because of the somewhat obscure manner in which such plants check surface run-off and erosion. The vegetation intercepts a small portion of the falling rain before it reaches the ground. The decaying plant material adds to or at least maintains the humus content and consequently the water holding capacity of the soil. The roots open up the soil to some extent and thus help the water to penetrate into the ground. The stems and leaves near the ground form physical obstructions to water as it runs down hillsides, reducing its velocity and increasing the chances of its being absorbed by the soil. The reduction of velocity and volume of run-off and the binding power of the roots check erosion.

On hillsides well covered with vegetation the run-off takes the form more or less of a sheet of comparatively clear water discharged gradually into the natural drainage channels. Such run-off does not contribute heavily to flood heads nor to the removal of soil from the slopes. On the other hand where grazing has materially reduced the plant cover and exposed the soil the run-off soon forms a system of gullies; the velocity and hence the eroding power of the water increases greatly in these gullies; the soil, gravel, and rocks torn loose and carried down add to the force and abrasive power of the water; and each succeeding storm cuts the gullies deeper, wider, and more directly down the slopes.

The result is a highly efficient drainage system that discharges a large portion of the rainfall into the regular drainage channels in a very short period, carrying great quantities of soil and contributing materially to flood crests. Very often by the time the gullies in such a drainage system have become well established so much of the better surface soil on the slopes has been removed that it is difficult for new plants to take root, and in order to bring back the vegetation special measures such as terracing and planting may become necessary.

Since grazing is one of the common uses of herbaceous and shrubby vegetation and, when not carefully controlled, is also one of the most common causes of the depletion of such vegetation, it should receive special attention on watersheds. Under average conditions,

where the cover has not already been reduced, grazing practice that will maintain the highest grazing capacity will also maintain the plant cover in a condition for satisfactory protection of the watershed.

Under special conditions such as where the slopes are very steep, the soil is easily eroded, or the cover has already been seriously depleted, it will be the best plan, in the long run, to graze very lightly or not at all. Such areas are of doubtful value for grazing at best and the danger from floods and erosion may more than offset any small returns from grazing.

Fox, Kel M. 1966. Cowboy on the Coconino. Journal of Range Management, 19(3): 153-155, illus.

The Coconino National Forest, located in north-central Arizona, has some of the best year-round grazing on the North American continent.

My family came to the Coconino in 1926, in the days of open range. There was only one drift fence on the Forest, running roughly east and west, dividing the range between the Little Colorado drainage on the north and the Verde on the south. Our ranch was on the Verde side.

Our country was divided into several units, each of which operated wagons during the spring and fall working seasons. We belonged to the Oak Creek wagon, named for the famous canyon that now attracts over a million tourists a year.

Our cattle were driven to points on the Santa Fe railroad, and frequently sold by the head rather than by the pound, as we do now. I missed most of the drives because I was away at school, but I do remember making one to Flagstaff, where we found the railroad pens full of cattle, making it necessary for us to night herd our bunch in 10 below zero weather.

Calf crops in those days were often below 50%. Death losses were high. Bulls were mostly "natives." Salting was casual. Some did. Many didn't bother. Wild horses, wild cattle and wild burros were plentiful, available to any wild cowboy who had the guts to run 'em -- and there were plenty who did, and some who made a fair living at it.

Our ranges were terribly overstocked, and I never heard the term "range management" until many years later.

The cattle were small and lean, and it was a good thing because they had to walk a long way to water. For many years we had just one dependable source of water on our summer country, a dam my father built at the headquarters place.

The Forest Service began fencing the open range into individual allotments in the late 1920's, and by the time the Great Depression rolled around most of the Coconino was fenced. Our allotment was called "Foxboro."

We were not only building tanks and improving our water situation, we were also taking the first, faltering steps towards more intensive management of our cattle.

Even bigger changes began coming after World War II. And they can be summed up in one term -- range management. All the outfits on our

part of the Coconino run cattle in the summer in the high country on top of the Mogollon Rim and winter in the Verde Valley. June 1 is the usual date for going from the winter to the summer country.

This created a problem for me. My cattle would drift from their winter range into a narrow canyon connecting the two ranges and hang up along the fence waiting for me to let them through. I spent many a hot, disagreeable day driving cattle from this fence back to water, only to see them return a day or so later. One spring I didn't catch them soon enough and lost eight head.

About this time I had an opportunity to buy some 20 sections of summer range adjacent to our old range. Included in the deal was some 400 acres of private land.

This purchase provided a chance to suggest a bold experiment. I proposed relocating the summer headquarters on the newly-acquired private land, where there was a fine spring and some wet-meadow pasture. The Forest Service was requested to build a fence from this point to the Rim. I would build a fence across the mouth of the dry canyon. These two fences would create a new unit, a range that could and should be used in the spring and fall. In effect, the ranch would now be divided into three main units: a winter range (House Mountain), a spring-fall range (Jack's Canyon-Jack's Point), and a summer range. The cattle would spend roughly 4½ months each on the winter and summer ranges, the other 3 months on the spring-fall range. Cattle could enter the new unit around April 15, gradually moving, on their own, through the canyon to the higher country. In the fall the process would be reversed.

The Forest Service was enthusiastic, and the plan was soon put in operation. Later I added a well and a branding corral at the mouth of the canyon and built a bull pasture.

The plan has proved to be very effective. The cattle now pretty much move themselves. Death loss has been cut to about 1%. My calf crop is never less than 90% and has been as high as 97%, with most of the calves coming in February, March and April. Calf weights at shipping time have jumped from around 395 lbs. to 480 lbs. Instead of branding at three different points on the winter range, we now brand virtually all the calves as they enter the spring-fall unit and, because we brand early, we rarely have a case of worms.

No cow outfit is, of course, without its problems, and mine is no exception. After 30 years of building tanks and drilling wells, I still find portions of the range that need more water. Juniper is a problem on some 5,000 acres. In my own lifetime I have seen lots of good grass land eliminated by the spread of pine thickets. A noxious plant, pingue, is a problem on perhaps 2,500 acres. My winter and spring-fall ranges get a rest during the summer growing season, but the summer range doesn't. It would be nice if we could work out a rotation system to accomplish this.

Frandsen, W. R. 1950. Management of Reseeded Ranges. Journal of Range Management, 3:125-129.

Much progress has been made during the last 15 years in seeding perennial grasses and legumes on submarginal and abandoned croplands and adapted areas of run down range in the Pacific Coast region of the Soil Conservation Service.

Grazing before the seedings are established, as well as the tendency to graze them too early, too close and for too long, are causing the early loss of some good to excellent stands. These losses occur frequently enough, in spite of warnings and instructions to prevent them, to cause some ranchers to seriously doubt the wisdom of range reseeding.

Seeded grasses are just about as delicate as the important native perennial bunchgrasses. Neither will hold up very long under excessive use. The regrowth of the more palatable grasses closely grazed in early spring will be repeatedly grazed throughout the growing season. This continuous grazing prevents the storage of needed food reserves in the roots, exhausts the stored food and results in early starvation and death.

Crested wheatgrass (Agropyron cristatum) is the most widely seeded bunchgrass on spring-fall range in the northwest. Harding grass (Phalaris tuberosa variety Stenoptera) is the favorite species for reseeding in central California. Fortunately, both of these are relatively resistant to close grazing if protected until they are firmly anchored in the soil. However, these two "wonder" grasses will respond to conservative grazing with increased growth.

Management practices which apply equally well to seeded and native perennial bunchgrass ranges:

1. Grass or Forage Management Practices

    a. Rotation and deferred grazing
    b. Proper utilization
    c. Fire prevention and protection.

2. Facilitating or Enabling Practices

    a. Stock water developments
    b. Fences
    c. Salting
    d. Feed reserves

3. Special Forage Improvement Practices

    a. Brush control in established seedings
    b. Range fertilization
    c. Reseeding site selection.

Freeman, John D. 1959. Rotation-Deferred Grazing on Dryland Ranges. University of Arizona, Agric. Exp. Sta., Special Report #2, pp. 13.

Rotation-deferred grazing is a system of grazing which provides for "deferment" (delaying grazing until seed is ripened) for each pasture every two, three or four years in a systematic order.

New growth buds are located in the crown on soil grasses, but are from one to six inches above the crown on some of the more productive bunch grasses. If the buds are grazed off and killed, it may take half of next year's growing season for the plant to generate new buds and start growing again. If half the growing season is lost this way, you may well lose half the feed crop, also. A good rule of thumb to remember is to leave half the feed for the plant and graze the other half. Each year your half will get larger. Ungrazed grass left on the range is definitely not wasted, it is invested in next year's crop and those for many years to follow.

We are blessed in most of Arizona with a climate suitable for yearlong grazing. This beats the old pitchfork method of winter feeding. But it is hard on the grasses and giving them first consideration, we must remember that even with conservative yearlong use a good range will go downhill and a poor range will be prevented from improving.

We have learned that the greatest production on irrigated pastures can be obtained if large herds are turned into small pastures for a short period of time. Stock will graze all plants uniformly and will then be moved on to the next pasture. Plants thus have plenty of time to recuperate before they are grazed again. The principle is the same out on the dryland ranges. If cattle are shifted from one pasture to another several times a year, they do not have time to become selective in their grazing. They are more apt to graze all forage plants as they come to them.

It may require some fencing and sometimes some additional water development to get a rotation-deferred system set up and going. This additional cost is usually more than offset by the many advantages such as the necessity for fewer bulls, less maintenance at watering places, greater ease in checking on cattle, the need for fewer cowboys on larger ranches, and greater forage production.

After the system has been in effect for awhile, the cattle get used to the idea of moving. They become gentler and easier to handle. They know they are going to fresh feed and they like it. The biggest payoff is in production of better and more forage.

Rotation-deferred grazing has been used for several years and has been proved successful in the Pacific Northwest and in Texas. It is rather new in Arizona, but is gaining favor with the ranchers. It is a proven method for increasing grass production and that is what we are looking for.

Freeman, John D. 1961. Society Members Develop Grazing Plan. Journal of Range Management, 14(2):70-71, illus.

The 13,000 acre "One Slash One" ranch is located 20 miles west of Prescott, Arizona. The vegetation is mostly Turbinella Oakbrush intermingled with blue, hairy and sideoats grama grasses. The elevation is approximately 4500 feet with an average annual rainfall of 14 inches and a growing season extending from July 1 to September 30.

In 1957, a four pasture rotation-deferred grazing plan was developed for the ranch by Milton D. Webb (ranch owner), Henry E. Wall (S.C.S.), and Fred Patton (ranch foreman). One or more pastures were rested during the growing season, and use of the other pastures was rotated so that any pasture was not grazed more than half of any one growing season, or at the same season in any two successive years.

Before the system was developed, four breeding herds were kept on in each pasture yearlong. Now there is only one herd, aside from replacement yearling heifers and bulls that are run by themselves when not with the cows.

After two years, observed results were as follows:

1. Having the cows all together made them easier to look after and cut down on riding. It also provided an opportunity to observe grazing habits and forage plant reaction.

2. Salting away from water allowed perennial grasses (mostly dropseed) to grow near the watering places and blue grama plants on some hillsides doubled in size.

3. Grass management was more effective than erosion control measures in getting new grass established. In two years, with management, grass had started in all the gullies.

4. Moving cattle during the winter produced no observable ill effects.

After two successful years of rotation-deferred grazing on his own four units, Webb decided to add the Forest allotment to make a five-year, five-pasture, rotation-deferred grazing plan for the entire grazing area.

Freeman, P. V. R. 1964. Report of Administrative Study on Demonstration Allotment - Main Pasture. U. S. Forest Service, R-2. 7 p. typewritten.

The Main Pasture demonstration allotment is located in the Crow Valley division of the Pawnee National Grassland in northeastern Colorado. Elevation is about 5,000 feet above sea level and precipitation averages about 12 inches annually.

The area is in the central Great Plains and is characterized by short grass vegetation. The principal forage species are blue grama, western wheatgrass, buffalograss, needleandthread, Junegrass, squirreltail, green needlegrass, and sand dropseed.

Prior to 1960 this allotment was used on a season-long basis. In 1960 a 4-pasture deferred-rotation was initiated. Each of the four pastures is used in rotation beginning with a different pasture each year.

The stocking rate in 1960 was approximately 4½ acres per AUM. The 1963 stocking rate was approximately 3-3/4 acres per AUM.

Utilization studies indicate that the 4-pasture rotation has affected distribution of use:

Percent of Area in each Utilization Category

Use Category	1959	1960	1961	1962	1963
Very Heavy Use	--	1	1	4	9
Heavy Use	24	20	17	7	20
Moderate Use	30	57	33	60	41
Light Use	46	22	49	29	30
Climatic Remarks	?	Dry season 3rd driest in 24 years.	Ave. Season	Ave. Season	Ave. Season Poor seasonal distribution

Without some type of improved management it is doubtful if the cattle could have safely been kept on this pasture for the full season in 1960 and 1963. Areas of poor soil stabilization are showing revegetation which should be reflected in the transect readings.

The use of rotation where there is a mixture of types, which is the common situation, will tend to protect the heavily used sites. This is borne out in the season-long pastures where once an area develops high palatability it is then kept closely cropped the rest of the season with no opportunity for recovering. Under rotation even though a site is closely cropped there is a provision for recovery either in the same season or in the succeeding seasons.

At the start of the rotation it was felt that the block used first in the season would be the most sensitive to overuse. It rapidly became apparent that the block used second in the rotation was the most sensitive as this block had not completed its growth when the cattle came on and usually had little opportunity for regrowth after the cattle went off. Therefore, we are following the practice of moving off the second block before all the feed is consumed, so as to allow a good carryover of old forage into the succeeding season, when it will be used first. This practice paid off handsomely in block 2 in 1963 as without the carryover feed turnout would have had to be delayed several weeks.

Members of the Crow Valley Association are requesting more rotations be established even though they realize that this will increase their improvement maintenance costs.

Several sidelights have developed which from the Range Manager's standpoint are extra dividends but to the rancher are dollars in the bank. One is the lesser territory to be covered by the bulls and consequent improved condition of the bulls and higher calf crops as well as reduced riding to assure good bull distribution. Another is the increased condition on the cows. It is very noticeable that the cows on this rotation are in the best condition of any cows in the area by fall. It has not been possible to get a check on calf weights but calves from this pasture do sell at the top price at the annual Association sale. These items are related to the data being assembled at C.P.E.R. which show conclusively that a bounce in gains is obtained every time a group of cattle is moved to a fresh pasture even though the pasture they leave is lightly grazed.

General observations indicate plant composition, density, and vigor are better than before the rotation was set up.

Frischknecht, Neil C., Lorin E. Harris, and Harry K. Woodward. 1953. Cattle Gains and Vegetal Changes as Influenced by Grazing Treatments on Crested Wheatgrass. Journal of Range Management. 6(3): 151-158, illus.

At Benmore, Utah, trials are being conducted to determine the proper intensity and best method of grazing cattle on crested wheatgrass. The elevation is approximately 5,800 feet and average annual precipitation is about 12 inches. Soils are mainly loam.

The area was fenced and seeded between 1938 and 1940 by drilling crested wheatgrass with small amounts of several other grasses directly into existing stands of Russian thistle.

Twenty-four 100-acre pastures were divided into two blocks of 12 pastures each. Twelve treatments consisting of all combinations of four methods and three intensities of grazing were allotted at random to each of the two blocks of pastures. Methods of grazing included: (1) rotation, with cattle being shifted periodically among three sections of the pasture so as to graze each section twice during the season; (2) continuous; (3) 10-day deferred, where grazing starts 10 days late; and (4) removed 10 days early at the end of the season. Pastures in the first two groups are grazed by cattle for approximately 60 days in the spring, and those in the latter two groups for approximately 50 days.

Planned intensities of utilization are: light, 50 percent; moderate, 65 percent; and heavy, 80 percent of current year's growth. These rates were achieved rather closely.

Grazing usually begins between the 15th and 25th of April at a time when crested wheatgrass averages between 3.5 and 4 inches in height.

Results reported in this paper cover the first 4 years of the grazing study.

Average daily gains (adult cattle- spring 1948 to 1951):

	Intensity of Grazing			
Method of Grazing	Light	Moderate	Heavy	Average
Rotation	2.80	2.76	2.02	2.53
Continuous	3.07	2.86	2.17	2.70
10-day deferred	2.97	2.82	2.24	2.68
10-day short	3.28	3.18	2.40	2.95
AVERAGE	3.03	2.90	2.21	2.71

Cattle in the rotation treatment averaged slightly lower daily gains than for any other method of grazing. McIlvain and Savage (1951) reported similar results on native vegetation on the Great Plains, but found that gains increased when animals were rotated at more frequent intervals during the summer.

Average daily gains (calves - spring 1948 to 1951):

Method of Grazing	Intensity of Grazing			
	Light	Moderate	Heavy	Average
Rotation	1.88	1.84	1.65	1.79
Continuous	1.91	1.91	1.78	1.87
10-day deferred	1.84	1.87	1.74	1.82
10-day short	1.85	1.88	1.77	1.83
Average	1.87	1.87	1.74	1.83

Average pounds of gain per acre (adult cattle - spring 1948 to 1951):

Method of Grazing	Intensity of Grazing			
	Light	Moderate	Heavy	Average
Rotation	30	36	35	34
Continuous	30	35	33	33
10-day deferred	28	36	38	34
10-day short	29	38	33	33
Average	29	36	35	33

Light grazing permits some plants to go ungrazed each year. The dry growth of these "Wolf" plants is relatively unpalatable to livestock and because of it such plants are not likely to be grazed in succeeding years.

Considering the light intensity alone, rotation grazing allowed only one-sixth as much old growth to accumulate, as the other three methods, because all animals were confined to one-third of a pasture at any given time, thus making for more uniform utilization.

"This far, few or no differences are discernible as a result of grazing treatment." However, fewer young plants are now being produced under heavy grazing than the other two intensities.

Griffiths, David. 1901. Range Improvement in Arizona. Bureau of Plant Industry, Bull. 4. 31 pp.

This is the first report on experiments with grasses and forage plants conducted by the Department of Agriculture through this office in cooperation with the Agricultural Experiment Station of Arizona, located at Tucson. The report contains an outline of the experiments undertaken on the tract of public land set aside by the President of the United States for the use of the Secretary of Agriculture in this work. The existing conditions and the present character of the forage supply on the ranges is fully described. The urgent needs of the stockmen for better range conditions are clearly set forth. The publication of this report now will be most timely as it brings before the public questions of the greatest importance to one of the largest interests of this country--the raising of livestock. While there are many forage problems of great importance which are now being worked out through this office, there is none, we believe, of greater importance or more general interest than that of range improvement. The free-range system has led to the ruthless destruction of the native grasses which once covered the magnificent pasture lands of the West, and the time has now come when active measures must be adopted to remedy the evils that have resulted from overstocking and mismanagement. It is evident that laws for the proper control and preservation of the ranges are not only essential to the stock interests, but also to the general welfare of the country. The matter is of as much importance to the irrigation farmer as to the cattleman, for the gullying of river channels during recent years, and the cutting of deep gorges in every slight depression, destroying the tillable lands, are directly traceable to the influence of close grazing.

Prof. R. H. Forbes, Director of the Arizona Agricultural Experiment Station, in an exceedingly valuable and interesting paper on the subject of "The open range and the irrigation farmer," read at the meeting of the American Association for the Advancement of Science held in Denver the present season, and which was published in The Forester, made the following most suggestive notes in relation to range improvement, which we venture to quote here:

> "The objects of range study are, in the first place, to demonstrate economic methods for the improvement and reclamation of the great areas of devastated, worn-out grazing lands of the semi-arid regions, and, finally, to suggest such administration of the country thus reclaimed, or the yearly decreasing areas of yet unruined ranges, that the interests of all concerned--the stockmen, the irrigation farmer, and the possible investor in the storage propositions of the future--may be brought into harmony with each other as well as be individually bettered.
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> *   *   *   *   *   *

"In view of the difficulties and failure which have been encountered in this direction (range improvement) and in view of the successful operations of the forest-reserve system, it seems to me that we can turn with some hope of success to the idea of range reservation in Arizona and New Mexico. The Government is there yet in control of great unbroken tracts of its public lands, and those Territories afford a most favorable opportunity for the institution of the experiment on a large and convincing scale.

* * * * * *

"The carrying out of such a plan by impartial and authoritative means, including provisions for a proper economic and scientific study of the problems involved, ought in time to vastly improve the range for the benefit of the stockman, and also to render the operations of the irrigation farmer and of the storage-reservoir promoter much more certain of returns."

On all the western stock ranges which the writer has visited there have existed many small areas in cultivated fields, unused pastures, fenced railroad rights-of-way, and similar situations which are in their virgin state or have so far recovered from overstocking as to bear testimony to the original productivity of the soil. Things are far different in large areas of southern Arizona. Here unused pastures are very rare, cultivated fields are fewer in number, and the destruction is so complete that in many localities even the railroad right-of-way has recovered but little in three or four years' time. On the river bottoms a few indications of luxuriant growths of grass are found, but in nearly every case, even in such favored localities, there is little aside from this evidence, the actual original conditions being very much modified. It would be but fair to state, however, that the season in which the region was first visited was an unfavorable one, being at the close of an exceedingly long dry period, when even evidence of forage was scanty.

Many ranchers, farmers, and prospectors who have lived in the country a long time have given much information relative to former conditions, some certainly reliable and some doubtless extravagant, as is apt to be the case in such matters. From the evidence given by every old settler no conclusion could be reached other than that of misuse of the range country and that the destruction was greater than in the more favored ranges of the Northwest. How the destruction of the range could be so nearly complete is somewhat beyond the conception of those not familiar with the character of the precipitation, configuration of the land, composition of the soils, and the habits of the forage plants of the region. With the exception of the annuals, the grasses are nearly all known as "bunchgrasses," a designation which indicates that they are not turf formers. Even the blue grama (Bouteloua oligostachya), which forms such handsome and persistent sod over vast areas on the ranges of the northwest, grows here in bunches. This prevailing

characteristic, together with the susceptibility of the surface soil to injury by the trampling of cattle, probably accounts in a large measure for the extent of the denudation of the range. During a season of rain the surface of the ground is badly cut by the cattle that tramp over it. After the February rains the depth of footprints in an average mesa region is one-half an inch to 4 inches, the deeper ones being in the lower moister regions, which are best suited to the growth of vegetation. It will be readily seen that a herd of cattle do immense injury to the surface of the ground by traveling over it during a season of rain. Regions which have survived close pasturage are very liable to be destroyed or greatly injured in this way. During the dry seasons the injury from trampling is nearly if not quite as great. Having no turf of leaves and no protection of shallow roots, the surface soil is easily cut and reduced to dust by animals moving over it in search of food and water.

The range improvement work in Arizona being of a different character from that usually contemplated, and being in a region more completely divested of range grasses than any other in the entire country, required considerable careful study in advance to discover the proper locality for experimentation. Accordingly, the greater part of a week was spent in a survey of the surrounding country in the vicinity of Tucson for the purpose of determining which of the three typical areas (mesa, foothill, or river bottom) would be the most favorable and give the most conservative and valuable data upon which to base judgment of the results obtained by experimentation. Finally a rather favorable mesa area was selected at an altitude of about 2,600 feet above sea level and about 400 feet higher than the city of Tucson. This tract, which was subsequently reserved from entry at the request of the Hon. James Wilson, Secretary of Agriculture, is described in the Government surveys as secs. 26, 27, 34, and 35, T14S, R14E, Gila and Salt River meridian.

Somewhat diagonally through the center of this area runs the Southern Pacific Railway, and a short distance to the east of it is located Wilmot Siding. The soil is a clay loam, mixed with considerable sand, and subtended at a depth of 2 to $2\frac{1}{2}$ feet by a calcareous hardpan, known among the Mexicans by the significant name "caliche." The slope, which is rather gentle, has a general northwesterly direction, and is traversed by three more or less distinct, broad, shallow depressions, which receive the drainage of a considerable area of land to the southeast. Such a region, with broad, shallow washes, was purposely selected. It was the intention to attempt to conserve water flow on the mesa, and to discover what can be done toward preventing "run-off" of water during the rainy season of July and August. Such washes, although the most favorable for the growth of vegetation of all kinds, are nevertheless typical of large tracts of desert, not only in the Santa Cruz, but in the San Pedro, Gila, and Salt River valleys as well.

A triangular portion of this reservation, consisting of 336 acres adjoining the Southern Pacific right-of-way, has been placed under a substantial four-wire fence supported on singed mesquite posts 13½ feet apart. The area encompasses nearly all the varieties of exposure, drainage, and soils and is, in short, a typical mesa region in every respect. The advantage taken of the railway fence enabled us to inclose the tract at a minimum cost. Two miles of fence, at an approximate cost of $150 a mile, covers practically the entire expense of the inclosure.

When selected, this tract of land, like the surrounding region, furnished practically no feed; the ground was bare, except for cacti and shrubby growths of little or no forage value. On the higher and poorer soils are found characteristic growths of the creosote bush (Larrea mexicana), around the base of which is almost invariably found Perezia nana, which, unlike the vast majority of desert plants, possesses a very pleasant odor. Scattered over the entire area are to be found luxuriant growths of cacti, mainly of the genus Opuntia. The main species of this family are O. fulgida, O. spinosior, O. arbuscula, O. engelmanni, Cereus fendleri, C. greggii, Echinocactus wislizeni. All of the lower areas have scattering growths of mesquite (Prosopis velutina), palo verde (Parkinsonia torreyana), Zizyphus lycoides, Lycuim sp., Riddellia cooperi, Bigelovia sp., and Ephdera trifurca. A few specimens of Yucca elata are also to be found. These plants formed the conspicuous portion of the vegetation in September, when the land was selected, and there was no grass except an occasional tuft of six-weeks grass (Bouteloua aristidoides) and low grama (Bouteloua polystachya). Soon after this date the tract assumed a more promising aspect, and weedy growths of various kinds began to spring up after the very light summer rains. It was not until January, however, that the vegetation became marked. From this time on until the 1st of March there was an abundant development of short-lived annuals. The most conspicuous of these was the California poppy (Eschscholtzia mexicana), which was so abundant in localities here and in other portions of the valley as to give its characteristic golden hue to the entire landscape, sometimes for many acres in extent. The next in abundance was Indian wheat (Plantago fastigiata), of which a description will be found elsewhere. Besides these, there were a great many borages, which were often the characteristic vegetation over large areas. The principal genera of this family represented were Pectocarya, Echidiocarya, Amsinkia, Echinospermum, and Eretrichium. Among other conspicuous plants may be mentioned Malacothix glabrata, Chaenactis lanosa, Daucus pusillus, Bowlesia septentriolis, Erodium cicutarium, E. texanum, Salvia columbarie, and the peculiar Enothera scapoidea. In a few localities conspicuous growths of the prickly poppy (Argemone platyceras) were to be seen. The latter was quite persistent and continued to bloom until June.

Summary and Suggestions

1. It being evident that the present unproductive condition of the range is due in the greatest measure to overstocking, it is desirable that some form of control of our public lands be devised whereby this practice, inevitable under present conditions, will be discontinued.

How this desirable end may be reached does not appear clear, but it is evident that laws for the proper control and preservation of the ranges are essential, not only to the stock-growing interests, but also to the general welfare of the region, that the rains may be better conserved and prevented from disfiguring the surface of the country to an extent absolutely beyond the conception of anyone who has not had experience with these easily eroded southwestern soils. The matter is of as much importance to the irrigation farmer as to the stockman himself, for the gullying of river channels during recent years and the cutting of deep gorges in every depression, thereby destroying the tillable soils, are directly traceable to the influence of close grazing.

2. Just control based on a system of land rentals which properly recognizes the rights of all ranchers located on the public ranges, would, it is believed, meet with popular approval and beneficial results.

3. The perennial grasses have been completely destroyed on large portions of the range. With absolute rest these areas would probably be reseeded in time, but it is believed that much can be done to expedite the matter by collecting seeds of native perennial forage plants in regions where they still persist and sowing them in the more favored localities of the denuded range. As far as the experiments which have been conducted indicate, the blue grama (<u>Bouteloua oligostachya</u>) and the Australian saltbush (<u>Atriplex semibaccata</u>) are the most promising for this purpose. <u>Bromus polyanthus paniculatus</u>, wire bunchgrass (<u>Agropyron spicatum</u>), slender wheatgrass (<u>Agropyron tenerum</u>), and shadscale (<u>Atriplex canescens</u>) also appear to be of some value for this purpose. It is impossible, however, to make definite recommendations at this time.

4. It is very necessary to test the germination qualities of native seeds. The grass garden started on the University grounds has served a useful purpose in this respect. The fact that native seed do not germinate when planted does not indicate that the species may not be a valuable one for reseeding worn-out range pastures, for it often occurs that native seed for various reasons does not germinate well. It is suspected that some of the seed gathered last season was not mature. This fault is often unavoidable, either on account of the methods of fruiting of the plant or on account of the collector's lack of time to wait for maturity.

5. Experiments thus far conducted in reseeding the worn-out mesa pastures having been begun in the month of January, it is desirable that subsequent experiments be carried on during or just before the summer rains. July or November will probably prove to be the best months for planting in this locality.

6. Judging from the season of 1900, grass seed can be most advantageously collected in the month of October. Seed of the native salt bushes can be gathered at any time from October to January.

7. On account of the excessive erosion careful attention should be paid to all cultural operations, and implements should be drawn in such a way that the rainfall may be held and spread over as much land as possible. In other words, cultural operations which extend diagonally across the drainage will usually prove most beneficial.

8. Fifty-two acres of the fenced portion of the reservation are under cultivation. This area is divided into 60 plats, upon which have been sown about 40 species of forage plants.

Griffiths, D. 1910. A Protected Stock Range in Arizona. Bureau of Plant Industry, Bulletin 177, 28 pp., Illus.

The investigations really date from 1903, when a tract of land 49.2 square miles in area upon the Coronado National Forest was closed to grazing by arrangement with the Forest Service and in cooperation with the Agricultural Experiment Station of the University of Arizona. Since that time another small tract of nearly a section has been inclosed and cooperative arrangements entered into with four ranchers contiguous to the south and east line of the large tract whereby the investigations will be considerably benefited in extent of territory, diversity of conditions, and interpretation of results by practical range operators.

Before the inclosure of this area it was open range, and large herds have fed here for years. The cattle usually come over in the fall from the other side of the mountains and remain until the April round-ups. In the upper portion of the field there was once a ranch of one of the largest cattle companies of southern Arizona, which has always been heavily grazed, but much heavier in times past than during the last few years before the inclosure was made. All in all, it may be said that heavy pasturing was the rule here for many years previous to that time. A portion of the area farthest from water, mostly on the edge of the perennial-grass area, was grazed only during the wet season when it could be reached by stock. It was therefore in much better condition than that lying closer to the mountains, where water was more convenient.

The accumulation of dead herbage upon the surface of the soil of the area takes place very slowly. When the growth first dries up in the fall after a good rainy season there is an accumulation of, perhaps, a thousand pounds of dry matter to the acre. This is enough to make a big fire if ignited shortly after the dry season sets in. If left upon the ground for one year in this climate, however, it largely disappears, from the action of wind and weather, so that the accumulation, while surely taking place from year to year, is very slow. In this inclosure after six years of protection there is in no portion of it a complete ground cover during the entire year. There is, it is true, at the close of the rainy season grass two feet or more high in some places, but, as is characteristic of desert vegetation, it is thin and largely disappears before the next season. In the lower portion of the field, where the annual grasses predominate, the accumulation is next to nothing, but it gradually increases toward the higher level and is most abundant in the extreme southern portion of the inclosure. The occurrence of a dry year largely obliterates any cover that may have accumulated during the previous season. In short, even after six years of protection there is now in the lower portion of the field practically no ground cover, and in all probability there never has

been any. In the upper portion, while the growth increases under protection, there is yet only about half a cover on the ground during the entire year. In the upper country, at an altitude of 3,500 feet and upward, a large accumulation of dead herbage can be kept upon the ground under a good system of management, as is being done in some private and cooperative pastures in the region now, but below this altitude the ground cover is not a factor of much consequence, for the grasses are mostly annual. Of course, upon the swales which receive flood waters the galleta and other grasses make a large growth and protect the surface, but such areas do not occur in the inclosures here described.

It will be seen that the matter of growth is one of distribution of moisture, which is influenced by altitude. Our experience upon this inclosed tract seems to indicate that the natural restocking of the perennial range by new plants takes place at irregular intervals. The ratio of increase may bear no relation to the quantity of seed produced the previous year. In other words, a favorable season for seed germination following a poor season of seed production may develop vastly more seedlings than one of poor distribution of moisture following an abundant seed production. Since this area was fenced, there has been but one season when the production of perennial-grass seedlings failed almost entirely. On the other hand, there have been but two years in five when a decided increase was noticed, the increase in 1907 - 8 being enormously greater than any of the others.

Many attempts have been made to introduce forage plants in this section, both in the large inclosure and upon the holdings of private individuals in the vicinity. There is but one species that has given any beneficial results. Alfilerilla (Eurodium cicutarium) has been tried several times and in various situations. In brushy pastures in the upper foothills it has produced a thick mat of herbage some years, while in others the growth has been poor. All in all it has done well in patches, but only in the most favorable situations, in rather loose soil, where the grazing has been quite heavy and there is open mesquite brush. This plant grows in the winter; consequently, the shade furnished by the mesquite is at a minimum when the plant grows. It has taken four or five years for it to become well established.

Results in reseeding, so far as these experiments have progressed, can be secured much more satisfactorily by the use of seed of native forage plants than by the use of the seed of plants from foreign countries. But even with those the results are not commensurate with the expense of getting the seed and growing it. Much more satisfactory results have thus far been obtained by husbanding the native vegetation and grazing well within the capacity of the land to maintain stock. In short, so far as information gained from experiments thus far conducted is concerned, these lands, although very badly overgrazed, will return approximately to their original productivity under complete protection in about three average years. Complete protection, however, is not

necessary, though of course it will take longer to restore lands to their full productivity when grazing is practiced.

The rancher in this region is only half wrong when he asserts, as he commonly does, that the six-weeks weedy and low-quality grasses have recently taken the range and driven out what he calls "root grasses," or the more valuable perennials. It is only the last portion of the statement that is false. The perennials, or more valuable species, have, it is true, disappeared; but they were not driven out by annuals, but on the contrary, by the rancher's cattle.

The annual grasses of this region, such as Bouteloua oristidoides and Aristida bromoides, are not much relished by stock. They have harsh, hard glumes which penetrate the flesh. They dry up early leaving but little substance, and more than all this, they pull up by the roots when grazed and carry with them sand and dirt. They are therefore not eaten while the perennials are available. When the latter become impoverished by excessive grazing, the former flourish. The ranges have therefore at present a larger proportion of weedy annuals, not because the latter are more aggressive, but because the former have been impoverished and to a large extent in many sections killed out by overgrazing.

One thing at least has been conclusively proved in this experiment, i.e., that the perennials which once flourished here and which have been decidedly injured by stock will again regain their ascendency over the weedy annuals when given a measure of protection. The Bouteloua rothrockii and Bouteloua bromoides areas were not only less productive of these perennial grasses when the inclosure was made but were actually more productive of the annuals Bouteloua aristidoides and Aristula bromoides. The gradual encroachment of the perennials upon the region of annual grasses has been one of the most notable features since the area was inclosed, and is yet in all probability only partially accomplished.

The regaining of ascendency by the perennials is slow here, much slower than in regions favored by a more equitable rainfall. As elsewhere stated, it is only in an occasional season that seed of the perennials appears to find conditions congenial for growth. This, coupled with the fact that the annuals invariably encroach at this altitude whenever the perennials are injured, renders the process of recuperation slow here compared with that in northern regions of more favorable rainfall and a less easily eroded soil.

On the other hand, the increased growth of an even partially protected area is phenomenal. One of the inclosures completed very late in 1907 can be distinguished at the present time for miles by the difference between the character of its vegetation and that of the vegetation outside, and it has been grazed continuously at that, but only moderately.

Below an altitude of about 3,500 feet we come to the desert proper, where the summer grasses are mainly of the annual type, always have been, and probably always will be. Below this altitude the only perennial grasses are those which are favored by occasional irrigation, in long arroyos and swales, where the drainage from higher levels spreads out over them. There is no hope of establishing perennials upon the lower, unirrigated mesa lands. When rains are favorable the low-lying regions will produce some indifferent feed in the shape of annuals, and that is all that can be hoped for them.

The appearance of the feed upon the ground is deceptive in any desert country, but more especially in the area described in this bulletin. The growth is invariably thin, but it may be quite tall, especially in favorable years, making difficult an estimate of the quantity of feed produced. This is true of the growth in general upon a desert region. The most deceptive grass of all is the one locally known as black grama (Mulenbergia porteri). In early days this grass was exceedingly conspicuous, growing in tangled masses 2 to 3 feet high, both in clumps of shrubbery and in the open. The pioneer stockman calculated the productivity upon what he saw of this species, supposing that he was dealing with a grass of ordinary character. But the pioneer saw three or four-years' growth, for the culms of this grass are perennial, only the terminal joints dying back each season. When, therefore, an area is unpastured for a time there is actually an accumulation of feed from year to year of this grass and some others, while the ordinary grasses die and grow up again from the roots each year. The deception is really serious, as is readily seen if one mistakes three or four-years' growth for one and stocks the land accordingly. This is precisely what has happened in many cases. It is no wonder that some managers of stock companies insisted that the country could not be overstocked, nor, indeed, would it probably be if the production which the pioneer saw could be repeated with certainty each year.

There are really but two weeds in the inclosure, but they are both somewhat serious. One is one of the rayless goldenrods (Isocoma coronopifolia), not distantly related to the sheep weed and snake weeds of New Mexico, Texas, and northern Arizona. Here this plant has spread upward from the river bottom and now occupies the rocky ridges and mesas between the grassy section and the more level desert lands below. It has thickened and increased perceptibly during the last five years. The rainfall in the region where it is most abundant was very light in 1908, and it consequently made but little growth. No one can tell what the future of this plant may be; it is quite probable that the grasses unmolested would hold their own against its encroachments, but with the grassy vegetation weakened by grazing it may increase to such an extent as to crowd out nearly all of the valuable plants, as is done over thousands of acres in other regions by species of Gutierrezia.

Table I - Average yield of forage on plats of 21 square feet each in the fenced area on the Coronado National Forest.

Year	Season	Rainfall	Seasonal Yield		Annual Yield
		Inches	Pounds		Pounds
1903 -	(Spring - - - - - - -	3.29	520.55)	- -	791.02
	(Summer	7.48	270.47)		
1904 -	(Spring - - - - - - -	2.64	14.13)	- -	412.45
	(Summer	8.24	398.32)		
1905 -	(Spring - - - - - - -	20.70	799.00)	- -	1174.94
	(Summer	6.14	375.94)		
1906 -	(Spring - - - - - - -	9.88)	(a)		(a)
	(Summer	3.27)			
1907 -	(Spring - - - - - - -	7.98	435.88)	- -	1151.76
	(Summer	12.03	715.88)		
1908 -	(Spring - - - - - - -	9.36	300.88)	- -	1225.55
	(Summer	10.67	924.67)		

In the production of the two crops of feed which we have in the region of the Coronado National Forest two seasons of rainfall contribute. The season which produces the spring crop is much more indefinite than the one producing the summer crop and the crops themselves are very different. The spring feed consists of weedy annuals, and the summer feed of grasses, both annual and perennial.

The winter rainy season, as it is usually called, may begin as early as October and may last through April, or it may be foreshortened at either end and even almost disappear at times. The summer rainy season, on the other hand, is short, commonly better distributed, and occurs in July, August, and September. In the column in Table I showing rainfall, that recorded under the spring season fell between October and April, and that under the summer season in July to September. The rainfall of May and June is negligible and seldom has any influence on feed production.

The rainfall record is taken in the 204-acre pasture shown on the map.

In a general way the yield is dependent upon the quantity of rainfall. Quantity, however, is not the only factor, as will be readily seen. Its distribution is of extreme importance. This feature is not shown in the table. It can be shown only by a detailed account of the precipitation, which it is not considered necessary to publish at this time. The most important point of all brought out by the table is the comparative uniformity of production during the last years and the increase over earlier years. Both of these facts tend to show that the production of the field has been decidedly on the increase and that it may now be at its maximum, which was reached in about three years after its inclosure.

Much has been written about the rapid spread of the mesquite (Prosopis glandulosa) and other shrubby vegetation in Texas since the advent of flocks and herds, but the development of this class of plants is so much slower on the inclosed area referred to in this paper that it appears to have been in a large measure overlooked. It is, however, taking place just as surely as in Texas; the only difference is that the growth is much less than half as rapid.

The year previous to the inclosure of the large field a small crop of hay was cut over the best portion of its present area. This, however, was far from any water. Acres were harvested where there was no impediment to the mower. At the present time, six years later, there is not an acre in the whole field where there are no shrubs to interfere with the machine. They are still small, half an inch to an inch in diameter at the base, but large enough to stop a mower.

The main factor, though, in the opinion of the writer, has been that of fire. It is firmly believed that were it not for the influence of this factor the grassy mesas would today be covered with brush and trees, the same as the canyons, except that the growth would be smaller, owing to a more limited supply of moisture. In short, the same laws apply here that govern in our great prairie states, where the treeless plains were kept so by frequent fires. It is a very conspicuous fact that the continuance of the desert forest, up to the mountains upon the mesas, occurs where the soil is poorest; in other words, upon the lands which produced least grass, and, consequently, the smallest amount of food for fires. This fact is illustrated in one of the pastures, where there is an area of mesquite upon the gently sloping mesa. But this area is naturally poor soil, and its poverty, on account of location close to the terminus of a temporary stream, has been aggregated for many years by excessive grazing.

The lands under consideration in this paper appear to regain their original productivity in approximately three years of complete protection.

Evidence thus far secured seems to indicate that the best lands in the vicinity will improve under stocking at the rate of one bovine animal to 20 acres. The poorer lands take a correspondingly larger acreage for each animal. The areas that will carry now one head to 20 acres are very limited.

Brush and timber are encroaching upon the grass lands, due, it is believed, to protection from fires.

A ground cover is not a factor below an altitude of about 3500 feet. Although the maximum yield of forage may be reached in about three years of protection, improvements in quality of forage will probably go on longer through the continued supplanting of annual plants by perennials of greater value.

Thus far alfilerilla is the only introduced plant which has succeeded, and this only in the most favored situations. It does not appear to thrive in competition with the native perennial grasses at these altitudes when the latter are not grazed.

None of the other two hundred lots of seed sown have given any promise of success except those of three or four native species. These give beneficial results, but the cost is high.

Results seem to be secured much more rapidly by proper protection from overgrazing than by any other method.

Hafenrichter, A. L. 1957. Management To Increase Forage Production In The West. U.S.D.A., Soil Conservation Service, Technical Publication #128, 16 pages, illustrated.

The trend is definitely toward rotation grazing of irrigated pastures in the West. There is an encouragingly wide acknowledgment among farmers of greater yield of meat or milk by rotational grazing as compared with continuous grazing. Three- and four-paddock systems are common, but large operators and several operators of good herds on family-size farms are tending toward strip grazing. A few large operators are using forage harvesters and lot feeding. The intensity of the method used seems to depend on the capital investment the operator can make. Most operators can afford electric fences to effect rotation grazing.

The results reported by Chapin, et al. (1) for nonirrigated pastures west of the Cascades showed that yields were increased 28 percent when a 3-paddock system was used and compared to continuous use. On another soil type, but under similar climatic conditions, Hodgson et al. (2) obtained only 9.14 percent increase in favor of the rotational-grazing system. This small difference made them question the feasibility of the rotation system. Hence, in one important dairy area there appears to be an interaction between soil type or fertility level or both and system of grazing.

The work of Peterson and Hagan (3) using clippings to measure the effect of different regrowth periods on four mixtures on irrigated land shows that extending the regrowth interval from 2 to 5 weeks increased average forage production for the season by 92 percent. However, there were several important interactions of interest to pasture managers. The four mixtures originally differed only in the legume used. In all cases the legume portion of the mixture increased with the length of the regrowth interval. The difference was greatest with alfalfa, least with Ladino clover, and intermediate with trefoil. The percentage of grasses decreased in all cases to 20 percent or less when 5-weeks' regrowth was used, but the decrease was least when Ladino clover was used and most when alfalfa was the legume. The use of fertilizers was not reported.

These data give some indication of the effect of management on botanical composition, verifying results observed on farms.

Schudel (4) in western Oregon obtained a 46-percent increase in production with each of two pasture mixtures by increasing the regrowth period from 2 weeks to 5 weeks. The longer regrowth period resulted in a decrease in the percentage of the legume in the mixture containing Ladino clover and an increase in the mixture containing trefoil.

His work considered an added management factor: height of clipping. Ladino clover is favored with close clipping, especially with long regrowth intervals and trefoil with high clippings.

(1) Chapin, W. E., A. G. Law and A. L. Hafenrichter, 1955. Pasture mixtures for upland soils in northwestern Washington. Washington Agricultural Experiment Station Cir. 260, 13 pages, illustrated.

(2) Hodgson, R. E., M. S. Grunder, J. E. Knott and E. V. Ellington, 1934. A comparison of rotation and continuous grazing of pastures in western Washington. Washington Agricultural Experiment Station, Bulletin 294, 36 pages, illustrated.

(3) Peterson, M. L. and R. M. Hagan, 1953. Production and quality of irrigated pasture mixtures as influenced by clipping frequency. Agron. Jour. 45:283-287.

(4) Schudel, H. L., Oregon Experiment Station. Private communication to A. L. Hafenrichter.

Hamilton, J. G., Grover F. Brown, Harold E. Tower, and Wilkie Collins Jr. 1945. Irrigated Pastures for Forage Production and Soil Conservation. U.S.D.A., Farmers Bulletin No. 1973, 30 pages, illustrated.

Under the rotation grazing system a pasture is divided into three or more units and these units are grazed, irrigated, and rested in turn throughout the grazing season. This system favors maintenance of the vigor of stands, because it excludes close continuous grazing on any part of the pasture. The periods of irrigation and rest provide for uniform regrowth over the entire pasture area. The heavier rate of stocking for short periods and the uniform growth of forage facilitate uniform grazing, and utilization of the forage when it is most nutritious. Livestock are off the pasture during and immediately after irrigation, when the ground is wet and trampling would damage the sod. All these factors contribute to high yields. In a test at the Western Washington Experiment Station rotation grazing, as compared with continuous grazing, resulted in forage yields 9 percent greater.

For improved irrigated pastures the three- and four-unit rotation grazing systems are widely applicable. Under the three-unit system the regrowth period in each rotation cycle is twice as long as the grazing period, and under the four-unit system it is three times as long. A five-unit system, with a minimum of 5 days between the last irrigation before grazing and the first irrigation after grazing, is desirable for some pastures on very sandy soils. The rapid drying rate of such soils permits grazing 2 days after irrigation. The frequency of irrigation required and the summer growth rate of the pasture plants are good guides in determining the number of days that should be selected as the rotation cycle. Except for first grazing in the spring, grazing may be so planned as to harvest the forage when it has reached a height of 6 to 7 inches. Ordinarily, regrowth to this height is made in a period of 2 to 3 weeks if the soil is fertile and the pasture has ample irrigation. If spring growth is so rapid that the forage cannot be adequately used by the grazing animals, one pasture unit should be left ungrazed and its vegetation used as hay or silage. It is never advisable to irrigate the pasture during grazing or later than 2 days before grazing.

The rotation grazing system can be fitted into the management plan of any farm. Where it is desired to move high-producing cows, or fattening livestock, to new pasture every few days and have the clean-up grazing done by dry cows and young stock, each of the pasture units can be subdivided and the units can be irrigated and otherwise managed in pairs as a three- or four-unit system. On many farms periods between deliveries of irrigation water, necessary field arrangements in regard to irrigation or drainage ditches, and other factors may determine what rotation plan is best.

Under any system of rotation grazing, the same pasture unit should not be grazed first every year. Rotation of first grazing among the different units contributes to maintenance of plant vigor and yield.

Hanson, H. C., L. D. Love, and M. S. Morris. 1931. Effect of Different Systems of Grazing by Cattle upon Western Wheatgrass Type of Range. Colorado Agric. Expt. Sta. Bulletin 377, 82 pages, illustrated.

The range was located at an elevation of 5,100 feet, about 4 miles west of Fort Collins. It included most of the first foothill as well as the plain at the base. Only the plains portion is treated in this bulletin because this part furnished most of the grazing and was fairly homogeneous in vegetation and topography. Up to 1905 this area was open range. It was then fenced and used until July 1, 1920, as a horse pasture for breeding work. During the rest of 1920 it was not grazed. In the spring of 1921 it was divided into two pastures. The plains portion of each of these was about one-fourth of a mile wide and about three-fourths of a mile long. Beginning in 1921, one of these pastures was grazed continuously by cattle, the other was grazed by the deferred and rotation method.

The vegetation, chiefly western wheatgrass, in these pastures was typical of much of the plains adjacent to and between the lower foothills in Northern Colorado. Intensive studies have been conducted in these pastures from July 1926 to September 1930.

The deferred and rotation pasture was divided into two parts so that the plains portion (103 acres) was in one part and the foothills portion (126 acres) in the other. The cattle (Hereford cows and their calves) were kept off the pasture during the spring period, from about March 15 to about May 1, while the soil was moist and the chief grasses were growing rapidly. From about May 1 to about August 15, the cattle were allowed to graze only one of the two parts, but after about August 10 they were given free access to both parts. This procedure was continued for 2 successive years. During the next 2 years the part that had been grazed between May 1 and August 15 was not opened until after the latter date. Both parts, then, were protected every year from early grazing, and a 4-year rotation cycle was followed for later deferred grazing on each part.

The pasture (total area including foothills, 157 acres) that was grazed continuously was open to stock the year round. Usually grazing did not begin in the spring until about April 15. There was little evidence of grazing for several weeks, but there were numerous signs of trampling and sliding.

The mean annual precipitation at Fort Collins during a period of 41 years was 15.06 inches. It varied from 7.11 to 27.57 inches. Most of the precipitation came during the spring and summer months.

Since the period for most active plant growth is during April, May and June, it appears that well-distributed and ample precipitation during this period is more important than at any other time. According to this criterion, then, 1926 appears most favorable of these 4 years for plant growth, and 1929 and 1930 as the least favorable. These records are important in the interpretation of measurements and observations of plants later.

Unfortunately, exact data on the vegetation are not available for the pastures at the beginning of the experiment. Exact data were secured during the summer of 1929 after the pastures had been grazed under different systems for slightly over 8 years.

The question as to the effects of the different systems of grazing upon the vegetation in these pastures resolves itself, then, largely into one concerning the effects upon western wheatgrass. In regard to frequency of western wheatgrass there appears to be no effect of the different systems of grazing in these two pastures.

The conclusion appears valid, then, that the continuous system of grazing has either not been continued for a sufficient number of years on this pasture to have produced detrimental effects, or that the number of stock grazed in the continuous pasture is not excessive. In regard to abundance, however, there was a great difference. The number of stalks in the quadrants in the deferred and rotation pasture was 53 percent greater than in those in the continuous pasture. This was the chief difference expressed quantitatively, that was found between these two pastures.

Bouteloua gracilis grows well on clay soils and it is less abundant or lacking on sandy soil in Eastern Colorado. On a nearby overgrazed pasture, where the soil was similar, this grass had a frequency of 100 percent and it was very abundant forming a sod over most of the area. Observation indicates that over-grazed western wheatgrass is replaced by blue grama grass. In the deferred and rotation pasture, it had a frequency of 47 percent, in the continuous one, 73 percent. It was also more abundant in the latter pasture.

Eurotia lanata, or winterfat, one of the most palatable plants in this region, grazed closely by the cattle, had a frequency of 70 percent on the deferred and rotation pasture, but 0 in the continuous pasture. Senecio perplexus, also very palatable and much grazed by cattle in May and June, had a frequency in the former pasture of 70 percent and 40 in the continuous one. There were 591 stalks recorded in the former, only 85 in the latter. Stipa viridula, also relished by the livestock, had a frequency of 20 percent in the deferred and rotation pasture, but 0 in the continuous one. Schedonnardus paniculatus, which was grazed considerably and usually closely, had a frequency of 90 percent in the

former, 60 percent in the latter. All of these species indicate that the system of continuous grazing reduced the distribution and abundance of the most desirable grazing plants as compared with the deferred and rotation method.

Aristida longiseta had a frequency of 37 percent in the deferred and rotation pasture but 64 percent in the continuous pasture.

The data on some of the undesirable species lead to conclusions similar to those derived from the data on some of the desirable species. The most significant species appears to be Psoralea tenuiflora, which is never grazed, and may grow to a height of 2.5 feet with a top spread of about 2 feet in diameter. In the deferred and rotation pasture its frequency was 63 percent and its abundance 165 stalks. In the continuous pasture the frequency was 100 percent and the abundance, 544.

The number of stalks of desirable species and of immaterial species was greater in the deferred and rotation pasture than in the continuous pasture; but the number of stalks of undesirable species was lower. This strengthens the conclusion stated above that differences in the vegetation in 1929 were due at least in part to differences in the grazing systems.

Measurements during 3 years (1927, 1929, 1930) of the growth rate of Agropyron Smithii based on 10 clumps (2 to 10 stalks per clump) in the deferred and rotation pasture and of 10 clumps in the continuous pasture, are given in Table 9. In each year the total height attained as well as the length of the growing season were greater in the deferred and rotation pasture than in the other. The total heights were 2 to 5 centimeters greater, the growing season 1 to 2 weeks longer.

The data show that the average height of Agropyron Smithii shoots was 23 percent greater and that of Stipa viridula 33 percent greater in the deferred and rotation pasture than in the continuous pasture. In both cases the differences between the average figures, as given in Table 11, exceeds 3.3 times the mean probable error of the two averages. On August 1, 1927, similar measurements were made. In the deferred and rotation pasture (grazing not deferred this year) the average height of 100 stalks of Agropyron was 20.5 inches, in the continuous pasture 18.9 inches. The corresponding measurements for Stipa were 21.7 and 18.7 inches. Soil-moisture determinations in the 1928 season showed that the water content was slightly higher in the former pasture, so that the moisture supply may have been the determining factor, although differences in the vigor of the plants may also have been important.

The oven-dry weight of 500 seeds of Stipa viridula collected on July 9, 1926, was secured for both pastures. The weight of 500 seeds from the deferred and rotation pasture was 2.483 grams, 28.3 percent heavier

than those from the continuous pasture, which weighed 1.935 grams. A germination test in the Colorado Seed Laboratory on February 18, 1927, showed 32 percent for seeds collected on July 9, 1926, in the deferred and rotation pasture and 12 percent for those from the continuous pasture.

Heady, Harold F., Richard T. Clark, and Thomas Lommasson. 1947. Range Management and Sheep Production in the Bridger Mountains, Montana. Montana State College, Agric. Exp. Sta. Bull. No. 444. 30 pages, illus.

The project reported in this bulletin was initiated in 1926 for the study of the practicability of the system of sheep management ordinarily used on National Forest ranges in Montana, (2) the changes in species composition and carrying capacity of the forage crop under systematic management, and (3) the response of ewes and lambs to mountain forage in terms of weight gained or lost.

The College Allotment, an area of 3,788 acres, of which 2,956 acres are usable, is located on the east side of the Bridger Mountains north and east of Ross Peak in Gallatin County, Montana. The boundaries, for the most part, follow section rather than natural lines.

The range is rolling, with a general east exposure and a moderate slope, which rises in elevation from about 6,500 feet at its eastern limits to about 8,500 feet at the western edges of the usable area. Slopes are moderate, with only a few of the lesser ones of sufficient steepness to hinder free movement of livestock.

Average annual precipitation at Bozeman was 18.00 inches, 60 percent of which fell during April to September, inclusive. Temperatures varied between a minimum of -53°F. and a maximum of 112°F. The mean temperature for the six months for a 48-year record was 56.4 degrees F. The period between the beginning of growth until the end of the grazing period averaged 108 days and extended from May 17 to August 31.

It is customary on National Forests in Montana to confine use to once over the range, but both the once-over and a modified twice-over practice were given trials on this allotment. According to specifications in the original plan, the twice-over practice was used for nine years, 1929-36 and 1939. The once-over system was used for five years, 1937-38 and 1940-42.

The first time over the range under the twice-over system was a fast one during which the feed was "topped" to secure full use of the short-lived succulent weeds that mature and become dry by early summer. The sheep were at the high elevations by mid-summer and then were trailed to the low areas against their will to begin the second trip. This system allowed more time for the valuable grasses to mature seed and encouraged use of the coarse grass while it was young and tender.

The once-over system was designed to have the sheep cover the range in conformity with the development of the vegetation and to have them use the range progressively from low to high elevations during one trip only. On most sheep ranges ideal coordination between forage growth and time of use cannot always be obtained and because of this some forage having high value for lambs dries before it can be grazed.

The following points concerning the relative merits of the two methods became apparent with the preponderance of evidence favoring the once-over method:

1. On this range, with several thousand feet difference in elevation, the high areas were not sufficiently developed for use at the time the sheep reached them on the first trip of the twice-over system. On the other hand, the forage on the various elevational areas was developed to a degree, by the time use began under the once-over practice, to provide abundant feed with minimum damage to the range.

2. Trampling damage was reduced with the once-over system because: (a) the rate of movement was slow and there was little or no trailing; (b) the soil was firm and stable, and this prevented uprooting of the plants and puddling of the soil; (c) open herding was practiced at all times; (d) forage plants were larger, stronger, and less susceptible to injury than they were during the first grazing of the twice-over system; and (e) after the high range had been grazed, the end of the grazing season was at hand and the voluntary downward movement of the sheep eliminated unnecessary trampling because of forced trailing.

3. During the first trip of the twice-over system it was difficult to get the sheep into the timber, because they wanted to avoid vegetation with excessive amounts of dew. This disrupted the scheduled use by causing too much grazing of the open areas.

4. At the beginning of the second trip of the twice-over system the feed at low elevations had become overmature and largely unusable. With the once-over practice the forage plants at low elevations had an opportunity for regrowth and seed production throughout the remainder of the growing season.

5. Progressive movement from low to high range in one trip corresponded more nearly to the seasonal feeding habits of the sheep.

6. The men handling the sheep did a better job under the once-over system, for they were not continually moving camp.

7. The lamb gains during four of the five years of once-over operation exceeded those of any of the nine years of twice-over use. The average individual gain obtained while using the once-over practice was 0.477 pounds a day and for the twice-over 0.416 pounds, a difference of 0.061 pounds, or an added gain of 4.09 pounds for each lamb during the average 67-day grazing period. For the average of 951 lambs actually grazed each year during the 9-year period, the total additional gain would have been 3,890 pounds a year. Since numerous other influences entered into the lamb weights produced, the difference could be attributed only partially to the use of the once-over practice.

Hein, M. A. and A. C. Cook. 1937. Effect of Method and Rate of Grazing on Beef Production and Plant Population of Pastures at Beltsville, Maryland. USDA, Techical Bull. #538, 35 pp. illus.

The experiment herein described was planned in order to obtain more exact information as to the returns that may be expected from a permanent pasture on soil comparable in productivity with that used for cultivated crops when such a pasture is grazed by beef cattle that are not given any supplemental feed. The results are considered applicable to soils of moderate fertility in the Middle Atlantic States and in the eastern part of the Corn Belt.

Numerous articles and some experimental results comparing rotation grazing and continuous grazing of fertilized pastures by dairy cattle have been published. Rotation grazing with the application of fertilizers to pastures is an intensive method of management adapted to high-producing dairy cows, but it is not likely to prove profitable in general livestock production.

The Division of Forage Crops and Diseases of the Bureau of Plant Industry, in cooperation with the Animal Husbandry Division of the Bureau of Animal Industry, began in 1928 at Beltsville, Md., an experiment to compare continuous light grazing with continuous heavy grazing and continuous heavy with alternate heavy grazing. The results were measured in pounds of beef produced and in the effect of the various methods of grazing on the composition and permanence of the pasture flora.

The 18 acres of land used for the experiment is on the animal husbandry farm of the National Agricultural Research Center at Beltsville, approximately 15 miles northeast of Washington, D. C. It is gently rolling and for the most part slopes to the east. There is no tile drainage, but an open ditch along the east side of the field provides both surface and sub-surface drainage. The soil is predominantly Sassafras silt loam except near the ditch, where it is Ochlochnee silt loam.

The 18-acre field was divided into an 8-acre, a 5-acre, and two 2-acre pastures, with a lane connecting each pasture with the weighing yard, as indicated in figure 2. The 8-acre pasture (A-1) was intended to be grazed continuously at the rate of one animal unit to 2 acres, the 5-acre pasture (A-2) continuously at the rate of one animal unit per acre, and the two 2-acre pastures (A-3N and A-3S) alternately at the same rate as A-2 (one animal unit per acre).

In alternate grazing, it was originally planned to change the animals from one pasture to the other every 2 weeks, but after the second year the grazing period was increased to 3 weeks, which method was continued

through 1932. Neither of these intervals of alternate grazing appeared superior to continuous grazing as indicated in the pounds of gain per acre, and it was decided in the spring of 1933 to govern the period of grazing according to the growth stage of grasses and legumes. In 1933 and 1934 the periods of grazing were approximately as follows: (1) 4 weeks on A-3N; (2) 6 to 8 weeks on A-3S; (3) 6 to 8 weeks on A-3N; (4) 4 weeks on A-3S; (5) 2 to 4 weeks on A-3N. This method of alternating the cattle on the two pastures was designed to effect the consumption of all the herbage on a given pasture before the animals were moved. The 6 to 8 weeks on pasture A-3S during the early part of the season resulted in the accumulation of a heavy growth of rather mature herbage on A-3N, which, however, was consumed rather completely by the animals in the 6 to 8 weeks following. A-3N was grazed first in 1933 and A-3S in 1934.

Under conditions of the experiment, no significant differences were observed in the gains made by steers on pastures grazed heavily and alternately, and on pastures grazed heavily and continuously, at the rate of one head per acre over the 6-year period. The 6-year average gain per steer on the continuously and heavily grazed pastures at the rate of one steer per acre was 196 pounds, as compared with 194 pounds for those on pastures alternately and heavily grazed. Steers on the continuously and lightly grazed pasture, stocked at the rate of one animal to 2 acres, made an average gain of 287 pounds per steer, as compared with an average of 195 pounds for the steers on the pastures heavily grazed. The steers that gained the additional 92 pounds each were considerably better finished; they had grazed at the rate of 2 acres per head.

Average gain per acre for the 6-year period was 145 pounds for the lightly grazed pasture, 196 pounds for the continuous heavy grazing, and 194 pounds for the alternate heavy grazing.

Herbel, Carlton H. and Kling L. Anderson. 1959. Response of True Prairie Vegetation on Major Flint Hills Range Sites to Grazing Treatment. Ecological Monographs, 29:171-186, April, 1959, illus.

Native prairie has been the home of grazing animals for untold centuries. Prairie plants are eminently adapted to grazing, and moderate grazing use is not detrimental to their development. Climax grassland, when properly grazed, retains essentially its natural composition. Yet, when livestock are placed on range too early in the season, when they are left there too long, or when too many animals are confined to an area, grazing becomes so excessive that normal plant cover cannot be maintained. Numerous changes in the vegetation then occur. The rate at which these changes take place depends on the degree of abuse. They sometimes take place so gradually that deterioration may not readily be recognized until the plant cover has been greatly modified, but when prairie is grazed intensively major changes may occur within a few years.

The Flint Hills area supports a year-round cattle population of perhaps 500,000 head plus some 300,000 additional ones shipped there each year to graze during summer. Utilization of bluestem range pastures has traditionally been through summer grazing by cattle, the period of heaviest use corresponding with that of the three months of most rapid grass growth--May, June, and July. Cattle often remain until fall, and some bluestem pastures are stocked year-long.

The climate conditions of the Flint Hills are typical of true prairie. Average annual precipitation varies from 30 inches in the northwestern part to 38 inches in the southeastern part of the region. About 75% of the moisture falls during the growing season, which ranges in length from an average of 170 to 190 days. Elevations vary from 1500 feet in the central part of the region to 850 feet at its southeastern extremity.

The pastures in this study are typical Flint Hills grasslands, located 5 miles northwest of Manhattan, Kansas. The vegetation is predominately true prairie, with big bluestem, little bluestem, and Indiangrass making up at least 50% of the vegetation on climax sites. Kentucky bluegrass has invaded the entire area.

Six pastures of 60 acres each were included in the trials, and grazed from 1949 through 1955. Three of these were grazed season-long (May 1 to approximately the end of October) and 3 in a deferred-rotation plan. Season-long grazing was at 3 stocking rates:

Heavy --- 3.75 acres/A.U.
Moderate- 5.00 " " "
Light --- 7.50 " " "

The three pastures in the deferred-rotation group were lightly stocked on the average. All of the animals were placed on two of the pastures

during May and June while the third was being deferred. On approximately July 1 all these animals would be shifted to the deferred pastures in order to use the grass quickly and to allow summer protection of the two pastures grazed earlier. Toward fall, if the grass became short under this intensive summer use, the gates would be opened to allow free access to all 3 pastures. This treatment was rotated annually among the three pastures of the group so that the overall average stocking rate was 5 acres per animal unit.

No important change in the relative quantity of decreasers took place in the deferred pastures.

The climax vegetation remained virtually unchanged under light stocking on ordinary upland. There has been a decline in range condition in limestone breaks in pastures stocked both heavily and moderately, while the pastures in the deferred-rotation group have remained virtually unchanged and the lightly stocked pasture has shown an improvement in range condition.

Moderate season-long stocking resulted in closer use of the forage than occurred under deferred rotation stocking at the same average stocking rate.

Pasture	1955 Beef Production Per Acre (lbs.)
Heavy	63.4
Moderate	54.0
Light	33.8
Deferred-rotation	42.5

	1955 Forage Production		
Pasture	Ordinary Uplands	Limestone Breaks	Clay Uplands
Heavy	1318	1528	505
Moderate	1749	1499	1116
Light	2080	1916	968
Deferred-rotation	2132	1958	1259
" "	1836	1947	1358
" "	1887	2083	1422

Hickey, Wayne C., Jr. and George Garcia. 1964. Range utilization patterns as affected by fencing and class of livestock. U.S.D.A., Forest Service, Rocky Mountain Forest & Range Expt. Sta., Res. Note RM-21, July 1964. 7 pp. illus.

A study was conducted in north-central New Mexico to determine how fencing small watersheds and stocking them with different classes of cattle affected the grazing patterns at one location in the Rio Grande Basin.

Principal forage species were alkali sacaton and galleta. Average annual precipitation for the area was 13 inches. Three distinct topographic types existed on the watersheds--"Uplands", "breaks", and "alluvium." The three watersheds were grazed from October to May each year by various classes of Hereford cattle as follows:

Years	Fencing	Classes of Cattle
1954-55; 1955-56	Open range	Yearling steers
1956-57	Partially fenced	Mixed herd (cows of all ages, calves, bulls, yearling steers, yearling heifers).
1957-58	Fenced	Yearling heifers
1958-59	Fenced	Old cows and calves
1959-60; 1960-61; 1961-62	Fenced	Young cows and calves

Since each class of livestock behaved and grazed differently on the three topographic types, the results were presented by the year or years in which each class was used:

1954-55, 1955-56 -- Use during these 2 years of open range was predominately by steers. Grazing use during this period was fairly uniform. Yearling steers tended to graze outlying areas, walk to water, drink and rest, then walk back to distant localities before grazing again. Use around watering tanks was no heavier than it was in some of the more distant areas.

1956-57 -- Use by all classes of cattle produced fairly uniform utilization except on areas immediately surrounding the stock tanks where utilization of the principal forage species averaged 98 percent. Cows and calves tended to use the juniper areas or areas sheltered by the breaks. Cows spent a great deal of time around water. Bulls spent most of their time around water and seldom moved as far north as the other classes of cattle. Incomplete fencing of the watersheds funneled livestock into the area and nearly doubled the anticipated stocking.

1957-58 -- This was the first season the watersheds were fenced so that cattle could be kept continuously on each watershed during the grazing season. The watersheds were stocked with yearling heifers and although use tended to be slightly heavier on the more accessible terrain, it was quite uniform over each watershed. The heifers readily negotiated the steep rocky breaks to graze the uplands. When not grazing they spent a great deal of time on the rock bluffs looking around. The alluvial bottomlands were grazed as the yearlings traveled from the uplands to water and back. Utilization near the reservoirs was less than during any other year of the study. Yearling heifers were much more active than yearling steers and grazed an area more uniformly.

1958-59 -- The watersheds were stocked with weak old cows (7 years old or more) that calved in January, February, and March. During the first few days the cows grazed over large portions of the watershed. They then used accessible areas that were protected from the weather by pinyon-juniper clumps or ridges, and completely ignored the uplands. Cows continued to use these protected areas until forced out due to lack of forage.

1959-60; 1960-61; 1961-62 -- During these three years, the watersheds were stocked with young cows (coming 3 years old up to 7 years old) that also calved in January, February, and March. These cows also grazed over large portions of the watersheds during the first few days. Instead of moving to the protected sites, however, they moved to the open alluvial grasslands. They used the sheltered areas only to calve and during periods of inclement weather. As forage in the lower, alluvial grasslands declined, the young cows used the outer edges of the more difficult terrain. Utilization in the vicinity of water was heavier than at any other time except when all classes of cattle were grazed.

Utilization patterns on small watersheds grazed by yearling cattle were about the same before and after fencing.

On rough terrain more uniform utilization may be attained by grazing with yearling heifers. When grazed as open range, mixed classes give most uniform use.

Hickey, Wayne C., Jr. and George Garcia. 1964. Changes in Perennial Grass Cover Following Conversion from Yearlong to Summer-Deferred Grazing in West Central New Mexico. USDA Forest Service, Rocky Mountain Forest & Range Experiment Station, Res. Note RM-33, 3 pp.

The three San Luis experimental watersheds are 555, 471, and 338 acres in size respectively. This site lies in the transition zone between semi-desert grassland and woodland.

Annual precipitation for the area averages around 10 inches. The soils, which are alluvial, were derived principally from Mancos shale and cretaceous sandstone and are now severely gullied.

Principal forage grasses were alkali sacaton, galleta, and blue grama grass.

During the 6-year period ending May 1, 1957, the three watersheds were grazed by cattle yearlong; during the next six years they were grazed during winter months only (November through April).

Stocking rates were adjusted annually on the basis of herbage production. The objective was to utilize 55 percent of alkali sacaton.

Annual utilization varied widely, but much more under yearlong grazing than under deferred grazing. During the 6 years of continuous yearlong grazing, average utilization of alkali sacaton ranged from 11 to 87 percent in comparison with 32 to 70 percent under summer deferment (November through April).

Annual precipitation fluctuated yearly, but the averages for the two periods of study are similar. From 1952 to 1957 annual precipitation averaged 9.83 inches; during the second period precipitation averaged 9.38 inches.

During the yearlong grazing, ground cover index declined. Measurements taken in 1958 showed a greater decline in blue grama than in the other two species. Blue grama was reduced by 56 percent from the 1952 value while galleta averaged a 15 percent decline and alkali sacaton a 34 percent decline during this period.

Under summer deferment, the ground cover index showed a marked change. Alkali sacaton increased 400 percent, galleta increased an average of 359 percent. Average increase for blue grama was 206 percent.

The change from a declining ground cover index to an increasing one suggests conversion from yearlong to summer-deferred grazing was beneficial. This change in grazing was mainly responsible for the ground cover increases in alkali sacaton, galleta, and blue grama.

Hinton, Kip. 1963. Eight Good Reasons for Range Rotation. The Western Farm Life. September 1963. page 5.

"Too much grass goes to waste. Moving cattle every 30 days or so cuts back the weight gain." These are two common complaints voiced by stockmen of the rotation grazing management system.

"Not so," says Walter Ferguson, Jr., Cheyenne, Wyo., who with his father, and brother, Martin, runs 500 head of black Angus on the Green Mountain allotment in Medicine Bow National Forest. Walter Ferguson, Sr., 85, was born in the "grass years."

"We figure three days of good hard riding to move our cattle every 30 days from one pasture to the next," Ferguson explains, and the "move" is not just across the fence. "We move 'em slow and easy, and what little they drop in weight comes back quickly, with added gain, when they get that new grass in 'em," he continued.

Asked if it "bothered" him to see good grass still standing when the cattle are moved off pasture in mid-October, Walt Ferguson, Jr., replied simply, "It never bothers me to see grass. If it's there in the fall, I know it'll be there come spring when we need it again. We always leave grass on our private pastures."

Prior to the rotation system, the bottoms were being hit hard and the ridges got little use. After four years of rotation grazing (one complete cycle) there is plenty of grass left in the bottoms after the cattle come off. This situation has resulted in a minor problem on Green Mountain, according to Ferguson. He feels that in some of the bottoms the grass may be matting up too much.

"The cattle hit the grass when they first move in and take the early stuff. But they leave the bottoms because there's too much old grass mixed in. Then the new grass turns rank. Guess there's nothing we can do about it, though. It wouldn't do to burn it off, and we're not about to try mowing it," he explains.

The Fergusons' Green Mountain allotment is divided into four pastures of approximately 2,200 acres each. This allotment originally carried up to 800 head during the late 20's and early 30's. It was later reduced to 500 head for range protection during the middle 30's, and in 1957 the allotment was believed to be still about 50 percent overstocked.

Fergusons and the Forest Service held a consultation. Would it be another range cut, or could something be worked out to benefit all concerned? A program of rotation grazing was agreed upon. The Rocky Mountain Forest and Range Experiment Station at Laramie offered to conduct research studies to evaluate the effects of the new type of

management on the range vegetation. That year the Forest Service constructed approximately seven miles of range fence. It was decided no special water developments were needed. The wild iris in one meadow was increasing and a spraying project was planned. This job was cancelled when the meadow began to recover naturally. Given protection, the grass took over to crowd out the iris.

Today there are about 23 miles of fence, of which 15 miles is maintained by the Fergusons at their expense. They installed a water tank in No. 2 pasture, and Walt Ferguson figures it wouldn't be a bad idea to put another tank in No. 1 pasture.

One complete rotation took place from 1958 through 1961, and another round will be completed in 1965. The season is from June 1 to October 15, stocking 500 cows and calves. And there's serious thought of increasing the number of animals. What size increase hasn't been decided. "Sure, we'd like to see more cows on the allotment," say these cattlemen, "But we're not pushing. We like all that grass, too. And we'd hate to tip the balance. The pastures have got more and better grass in 'em than when we started five years ago."

The Fergusons agree the rotation system isn't perfect. Apparently, however, any drawbacks are more than covered by the advantages. The major grievance is moving cattle every 30 days, not because of weight loss, but the time involved. "But," he counters, "we don't have half as much riding inbetween moves. We can spend half a day in the saddle, see all our cows, and come home. Used to be on the single pasture, we might ride two or three days for a good check. Last fall, for instance, it took us only one day for roundup."

The biggest advantage? Calves. More of them, and even an even crop. The Fergusons are convinced they are getting much better coverage from the bulls. "The percentage is definitely up," Walt, Jr. emphasized.

Summing it all up, there are several major points usually cited in favor of the rotation grazing management system: (1) Desirable plant species are cropped once and given a chance to establish vigor through storage of food and regrowth; (2) Seed production on the preferred plants is improved on three of the four pastures every year--particularly the pasture grazed last each year; (3) Utilization is more uniform over each unit than in open range grazing, and young plants are better established; (4) Calf crop percentages may be higher and the calving season shorter; (5) Poorer plant species are being utilized to some extent under rotation grazing, whereas light or no use was observed on these plants under season-long grazing; (6) Watershed values are better as the plant cover is increased by new seedlings which are established; (7) This type of management permits deferment of areas infested with poisonous plants until the plants are cured and safe to graze; (8) Less riding is needed to obtain distribution, resulting in less trailing and tramping damage and better weight gain for range cattle.

Asked how their father, as an old-time, open-range cattleman tells about the rotation system when it was first proposed, the Ferguson brothers had this to say: "He went along with it. He likes to see tall grass, too."

Hodgson, R. E., M. S. Grunder, and J. C. Knott. 1931. Efficiency of Rotational Grazing. Washington Agricultural Experiment Station. Bulletin #260, p. 29.

A four acre bottom land pasture seeded in the fall of 1929 was divided into two equal areas. One pasture was used for continuous grazing while the other was divided into six one-third acre plots, and pastured rotationally. The two types of pastures were subjected to grazing by an equal number of cows. Other methods of management were identical for both pastures. The management of the groups of cows throughout the season was similar to that practiced in the conduct of the ordinary barn feeding trial.

To determine the yield of grass on the two pastures, a cut, consisting of three one-square yard areas, was made on each plot immediately after each grazing period on that plot. These areas were located in different parts of the plot and were protected from the animals by suitable wire cages. The total yield of the three areas was used as a basis for determining the percentage of dry matter in the grass and the yield of dry matter in pounds per acre. The sum total of all the yield cuts taken on a plot during the season represented the total yield for the season.

Similar cuts were made in the unprotected pasture after each grazing period to determine the amount of unconsumed pasture left by the animals. The areas from which residual cuts were taken after a given period were used during the following period for the yield cuts. In this way a different area was used during each grazing period, and a representative sample of the pasture was secured.

The amount of material grazed by the cows was determined by subtracting the current yield of residue from the current growth. After the first grazing period, the residue remaining after the previous grazing period was added to the current growth before subtracting the current residue.

The results of this season's work exhibit an 8.45 percent greater production of four percent milk per acre for cows on the rotational grazed pasture. This group of cows also made a 33.9 percent greater gain in live weight regardless of the fact they received 28.3 percent less dry matter per cow per day in the form of pasture grass.

Hodgson, R. E., M. S. Grunder, J. C. Knott, and E. V. Ellington. 1934. A Comparison of Rotational and Continuous Grazing of Pastures in Western Washington. Washington Agric. Exp. Sta. Bull. 294, 36 pp.

Permanent pastures that are developed to high state of productivity are the dairymen's cheapest source of feed. Pasture grass is the largest single source of nutrients used by dairy cattle in western Washington. Climatic conditions are such that this region is particularly well adapted to the development of highly productive pastures. There are many dairymen who have successfully demonstrated the economy of production through the development of high yielding pastures. The vast majority of the pasture area, however, is not producing at its maximum capacity.

The experiments herein reported were carried on through the grazing seasons of 1931, 1932, and 1933. Lactating dairy cows were used to determine the relative efficiency of rotational grazing as compared with continuous grazing of pastures. Rotational grazing as used in this report refers to restricted grazing of animals rotating over units of the entire pasture area. Continuous grazing refers to unrestricted grazing of animals over the entire pasture area.

The pastures were situated close to the barn and consisted of 1.95 acres each. They were established on typical muck soil. The pasture contained the following grasses and covers: Italian ryegrass (Lolium multiflorum), English ryegrass (L. perenne), meadow fescue (Festuca pratensis), tall meadow oatgrass (Arrhenatherum elatius), creeping bentgrass (Agrostis sp.), Orchardgrass (Dactylis glomerata), rough stalk meadowgrass (Poa trivialis), timothy (Phleum pratense), red clover (Trifolium pratense), alsike clover (T. hybridum) and white clover (T. repens). It was seeded in the fall of 1929 and received light grazing during the latter part of the summer of 1930. There was a good stand of pasture grasses with the various ingredients fairly well represented. At the close of each grazing season both pastures were top dressed with approximately 10 tons of well rotted stable manure per acre. Each spring 100 pounds of superphosphate per acre were applied. The cows were turned on the pasture on April 22, in 1931; April 27, in 1932, and April 26 in 1933.

While the same number of cows were maintained on the continuous and rotation pastures, the grazing rate of the rotation plots was always six times that of the continuous pasture because the cows were confined to one-sixth of the total area. The cows on the rotational pasture grazed over the units in succession. The frequency with which the cows were rotated over the pasture units depended upon the rapidity of growth of the grass and upon the time it took the cows to uniformly close graze the plots. Uniform close grazing was not entirely accomplished because the clumping in the pastures was not wholly controlled.

After the cows were removed from each plot the droppings were spread with a fork to aid in the prevention of clumping. The number of days that the cows were maintained on the plots varied with the condition of the grass and the ability of the cows to graze them closely.

The cows on the continuously grazed pasture were allowed to graze over the area at will. No attempt was made to control their grazing habits in any way. The droppings on this pasture were spread each time that the other group of cows had made a complete cycle of grazing over the rotation units. At the time the droppings were spread various noxious weeds that appeared in both pastures were removed.

Little difference could be noticed in the clumping effect of the continuous or rotational pastures. As the season progressed into July and August it was noticeable that considerable grass was pulled out by the grazing animals. This was probably due to quite close grazing, the newness of the seeding and the character of the soil on which these pastures were seeded. This condition was apparently more noticeable on the continuous pasture.

During this season (1931) the cows on rotational grazing gained 393.7 pounds in live weight, an average of 0.19 pounds per day more than the continuously grazed cows and produced an average of 3.60 pounds more milk per day. They consumed 0.15 pounds more grain per day but obtained an average of 1.42 pounds more total digestible nutrients from pasture than did the continuously grazed cows. They consumed slightly less supplemental feed per 100 pounds of milk produced than did the cows on continuous grazing. During the 140-day grazing period the cows on continuous grazing experienced a 25.4 percent greater decline in milk production than the rotationally grazed cows. This difference in the rate of decline in production is significantly in favor of the rotation group, especially since the average lactation and gestation periods at the beginning of the season were about the same for both lots.

The condition of the cows and their average milk production were higher at the beginning of this season (1932) - consequently more supplementary feed was fed. Both groups of cows made about the same gain in weight during the season. The continuously grazed cows produced 1.39 pounds more milk per day and obtained an average of 0.62 pounds more total digestible nutrients per day from the pasture. The supplementary feed required per 100 pounds of milk produced was 1.8 pounds less for the continuously grazed cows. The average rate of decline in milk production during the grazing season was 7.3 percent greater for the cows in rotational grazing.

The results show a distinct advantage in rotational grazing in 1933. This may be accounted for by the fact that there was insufficient early spring growth on the continuous pasture to tide the grazing animals over and they were required to close graze the entire pasture, whereas the vegetation in the rotation plots experienced the usual rest-recovery

period. The intermittent rain that occurred through the season was especially favorable to rapid growth of grass.

During the season the continuously grazed cows lost a total of 19.5 pounds live weight whereas the rotationally grazed cows gained 176.5 pounds. The average daily milk production of the continuous group was 43.6 pounds and for the rotation group 56.5 pounds. The average milk production per cow during the first two weeks of the test period was nearly the same, indicating that the difference in the seasonal production was not to be contributed to unbalanced groups of cows. The cows on continuous grazing consumed an average of .19 pounds more grain per day than cows on the rotational pasture and obtained 4.73 pounds per day less total digestible nutrients from pasture. The percentage of total nutrients required that was obtained from pasture was 84.15 for the continuous group or 3.11 percent less than for the rotationally grazed cows. The percentage decline in milk production during the grazing season was 23.9 percent more in the case of the cows on the continuously grazed pasture.

Conclusions

The cows on the rotationally grazed pasture for the three years produced an average of 3.75 pounds more milk per day and 0.1 pounds more butterfat than the cows on continuous grazing. The cows took from the rotationally grazed pasture an average of 950 pounds more total digestible nutrients per year than the cows on the continuous pasture. The continuously grazed pasture proved to produce more nutrients during the season of 1932. This situation was reversed in 1931 and 1933.

The cows on the rotationally grazed pasture consumed an average of 487.8 pounds or 8.87 percent more total digestible nutrients per acre per season from pasture than the continuously grazed pasture. The cows on rotational grazing produced an average of 874.7 pounds or 9.05 percent more four percent fat-corrected milk per acre than the cows on continuous grazing. The carrying capacity in standard cow days was 343.6 for the continuous pasture and 374.1 for the rotation pasture or 8.82 percent greater on the rotation pasture. A standard cow day represents a grazing animal receiving 16 pounds of total digestible nutrients per day from pasture.

It would seem from these data that rotational grazing alone does not improve the quality of pasture grass from the standpoint of its chemical composition.

Hormay, August L. 1956. How livestock grazing habits and growth requirements of range plants determine sound grazing management. Jour. of Range Mgt. 9(4):161-164. illus.

"To a stockman the main objective of a range livestock enterprise is sustained maximum livestock production and sustained maximum dollar income. These can be realized only when forage production on the range is maintained at a maximum level.

"The basic requirement for range improvement is proper management of grazing------For a given kind of livestock it (proper management) consists of the manipulation of only four factors: (1) Stocking rate, (2) season of grazing, (3) livestock distribution, and (4) frequency of range grazing. A range deteriorates or improves and livestock production is efficient or inefficient, depending on how these factors are applied.

"Most western ranges are covered by, or have the capacity to grow, bunchgrass type vegetation. This type of vegetation reproduces from seed. Improvement of the type for grazing depends mainly on getting reproduction of desirable forage species in the right places.

"Cattle,---, graze the range selectively, eating certain plants on certain areas more closely and more consistently than on others. Preferred forage species on readily accessible, preferred sites are utilized closely even under light or moderate stocking of the range as a whole."

"Now the unfortunate part about selective grazing is that plants and areas that are grazed heavily one season tend to be grazed heavily the next season, and those grazed lightly once tend to be grazed lightly again. Even during the season, livestock tend to regraze the same plants rather than eat ungrazed ones. This consistent pattern of use is the result of the grazing habits of the livestock.

"Therefore, under season-long grazing year after year, as now practiced generally on mountain ranges in California and elsewhere throughout the West, the better forage species on the more accessible and preferred grazing sites are gradually killed out.

"Clearly no livestock distribution measure can prevent selective grazing. Even on the smallest area, livestock tend to graze the palatable species and leave the unpalatable ones.

"There is no practical point on the stocking scale where close grazing of a part of the vegetation does not occur. Stocking rate simply determines the size of the closely cropped area and the rate of vegetation change due to grazing.

"Varying the season of grazing provides little opportunity for preventing injury to the vegetation, -----, close cropping is damaging to the vegetation practically throughout the grazing season--even when the vegetation is mature.

"Shifting livestock about to relieve grazing pressure on the vegetation at critical stages of plant growth is impractical. Time is too short. Furthermore, frequent moving of livestock reduces their total weight gains during the season.

"The harmful effects of grazing can be overcome by controlling the frequency of grazing, that is, by withholding grazing at intervals long enough to give all plants a chance to recover normal vigor, produce seed, and establish reproduction.

"A rest-rotation grazing plan provides positively for continuous establishment of reproduction, weather and site conditions permitting."

Hormay, A. L. and A. B. Evanko. 1958. Rest-Rotation Grazing--a management system for bunchgrass ranges. U.S.D.A., F.S., California Forest and Range Experiment Station, Misc. Paper #27, 11 pages, illustrated.

This paper states the same basic factors and principles as the previous article, with the following exceptions:

At Burgess Spring, we found that Idaho fescue--the most important single species on the range--needed one and a half seasons of rest to recover from the shock of close cropping, regain vigor, and produce seed. All in all, we believe that this amount of rest is probably adequate to insure seed production on most bunchgrass ranges in California and on similar ranges in the other parts of the West. Another season of rest was needed to assure establishment of seedlings after germination. On more arid ranges, say those with 15 inches or less of annual precipitation, two seasons of rest from grazing at time of seedling establishment would probably be better.

Table 1--Estimated cattle 1/ production from five different length grazing seasons in a rest-rotation grazing system.

Length of Season	Beginning and Ending dates	Growth stages of Idaho fescue at beginning of season	Stocking per Section	Seasonal weight gain per head	Weight gain per head per day	Weight production per acre
Months	Dates		Animal Units	Pounds	Pounds	Pounds
1	June 21-July 20	Flower stalks two-thirds grown	246	71	2.37	27.3
2	June 11-Aug. 9	Flower stalks one-third grown	123	130	2.17	25.0
3	May 22-Aug. 19	Flower stalks in mid-boot	76	182	2.02	21.6
4	May 22-Sept.18	Flower stalks in mid-boot	58	212	1.77	19.2
5	May 2-Sept.28	Basal leaves 3 inches tall	42	234	1.56	15.4

1/ Yearling heifers averaging 420 pounds.

Construction of fences, water developments, and other grazing management facilities was started in 1951 and by 1954 the range was under management. By 1958 each of the units on the allotment had been carried through one cycle of grazing treatments. Some natural reproduction has become established in each. Good stands of smooth bromegrass, crested wheatgrass, and intermediate wheatgrass were established by reseeding and are being maintained under the system. Native grass stands were thickened and maintained on areas sprayed with 2,4-D to hill out sagebrush. The allotment speaks for itself: the trend in range condition is definitely upward and grazing capacity is being increased.

Hormay, A. L. and M. W. Talbot. 1961. Rest-Rotation Grazing...A New Management for Perennial Bunchgrass Ranges. USDA Forest Service, Prod. Res. Rpt. No. 51, 43 pages, illustrated.

A study carried out on the Burgess Spring Experimental Range in northeastern California during a 16-year period (1936-51), and reported here, led to the design of a rest-rotation grazing system. Rest-rotation is now being tested on the Harvey Valley cattle allotment on the Lassen National Forest. This allotment encompasses about 25,000 acres of suitable livestock range, and it is grazed by 515 head of cattle for a 4-month summer season. The test was started in 1952 and is scheduled to run for 23 years.

On 97 percent of the range, forage is furnished primarily by bunchgrasses and other perennial plants that depend on seed for reproduction; on less than 3 percent, it is furnished by species that reproduce or spread vegetatively rather than from seed. Of eight cover types, the grassland, sagebrush, juniper, and pine types occupy 63 percent of the total area and furnish most of the forage used by livestock.

Cattle were grazed in three fenced units; one unit was on a representative area of cutover pine type, and two were on a representative area of grassland type.

Precipitation for a 12-month season averaged 18.1 inches during the 19-year period 1935-54. On the average, 74 percent of the total seasonal precipitation occurred during the 6 months from October 1 to April 1, mainly as snow. Twenty-one percent (3.8 inches) fell during the active growing season, April 1 through June. Only 5 percent fell during July, August, and September.

Growth began about April 1 immediately after the winter snowpack melted, and ended about 120 days later in early August when seed ripened. This growth was sustained mainly by moisture accumulated in the soil up to the start of growth.

In both the timber and grassland types, cattle grazed certain plant species and certain areas more consistently and more closely than others, resulting in very uneven utilization of the range. Though complex, the pattern of use was similar from season to season.

Practically every one of the 100 or more plant species in the timber type was grazed to some extent at one time or another during any given species. Twelve species supplied 95 percent of herbage taken by the cattle. Grasses supplied 61 percent, forbs 27 percent, and shrubs 12 percent.

Of the abundant species, six were grazed more consistently throughout the season than the others. These were Idaho fescue, bottlebrush squirreltail, mountain brome, wooly wyethia, longspur lupine, and antelope bitterbrush.

Groups of 10 plants of 4 species were cut with a knife to a 1.5 inch stubble at different growth stages, starting when the plants were about 3 inches tall and ending about the time of seed ripening. Each group of plants was clipped once during the season except where regrowth was produced. Regrowth was clipped when full grown. A single season of clipping materially reduced the basal area of the four species the next year. The basal area of Idaho fescue was reduced 49 percent, longspur lupine 59 percent, bottlebrush squirreltail 21 percent, and wooly wyethia 8 percent.

Clipping to a 1.5-inch stubble during the active growing season reduced the number and height of Idaho fescue flower stalks in the regrowth. The stunted flower stalks that were produced in the regrowth had little or no seed. Flower stalk production 1 year after clipping was severly reduced. Average reductions for 4 years ranged from 94 to 100 percent.

Apparently food for future growth is stored in the roots and stems of the plants mainly after the growth rate slackens. The amount of stored food is greatest about the time the plant ripens seed. The plant draws on these food reserves after it becomes dormant, throughout the winter, and also in the spring to start new growth. Thus defoliation at almost any time of the season is harmful to the plant, but it is especially harmful during rapid growth.

Four years of rest after 4 years of continuous clipping at the seed-in-milk stage resulted in little or no recovery of original basal area of the four species studied. Apparently the soil space released by the clipped plants was encroached upon by adjoining unclipped plants, and this encroachment prevented material recover of basal area of the clipped plants during the rest period. No flower stalks (Idaho fescue) were produced during the first year of rest. This indicated that the plants were low in vigor.

Use of Idaho fescue during the 8 years of grazing averaged only 32 percent. However, in 1946, grazed areas had 21 percent fewer Idaho fescue plants than comparable protected areas. The plants on grazed areas were 42 percent smaller and produced 31 percent less herbage per unit of live basal area. These effects combined represent a 68 percent reduction in yield of Idaho fescue in open areas, or 21.4 pounds per acre.

The average grazing season during the 5 years (1944-1948) began May 23 and ended October 21. During this period the heifers in the timber type gained 217 pounds per head; those in the grassland type 227 pounds, or 10 pounds more.

Gains continued for 136 days in the timber type, until October 6, then the cattle started to lose weight. The losses averaged 10 pounds per head up to October 21. In the grassland type, gains continued only 131 days, until October 1. From then until the end of the season losses averaged 17 pounds per head.

The nutritive value of herbage is highest when the plants are green and growing rapidly. The plant is most ideally balanced in minerals, vitamins, proteins, carbohvdrates, roughage, and moisture for livestock when approaching the flowering stage.

"As the better plants are destroyed, livestock graze on less palatable species and are forced into less accessible areas. This leads progressively to ever-enlarging areas of deterioration."

Although little if anything can be done to prevent selective grazing while the range is grazed, the harmful effects of selective grazing can be counteracted by resting the range from grazing at appropriate intervals so that all plant species--those usually heavily grazed as well as all others--have an opportunity to grow and reproduce normally. The rest rotation grazing system was, therefore, designed to make this possible and thereby increase forage and livestock production.

Hubbard, William A. 1951. Rotational grazing studies in western Canada. Jour. of Range Mgt. 4(1):25-29.

Dominion Range Experiment Station, Manyberries, Alberta, Canada. The purpose of the study was to determine the effects of deferred rotational grazing with continuous use of the range. Sixty miles NW of Havre, Montana.

The topography is undulating to gently rolling. The area is classified as short grass prairie, and is characterized by blue grama grass (Bouteloua gracilis), which comprises over one-third of the total vegetative cover, and by needleandthread (Stipa comata).

The animals used in the grazing trials watered at a centrally located well operated by a windmill. The maximum distance to water was two miles.

The test was run from 1932 to 1937 with a grazing season of seven months (average April 8 to November 3). The rotation made use of three fields of equal size for each intensity of grazing. The rates of grazing were 20 and 30 acres per head and each pasture was grazed for one-third of the season as follows:

Season	Field designations by letters and years					
Grazed	1932	1933	1934	1935	1936	1937
Spring	A	B	C	B	A	C
Summer	B	A	B	C	C	A
Fall	C	C	A	A	B	B

During the 6-year period each field had two seasons of spring grazing, two of summer, and two of fall use. This allowed the vegetation in each field to develop normally in two years out of six. The two years of protection during the entire grazing season came consecutively.

Ten head of uniform good commercial grade yearling Hereford heifers were placed in each set of pastures in 1932, and the same animals were grazed in the same fields in subsequent years. The heifers were bred at two years of age, and in each succeeding year, so there were calves with cows in the fields during the years 1934 to 1937, inclusive.

At the rate of 20 acres per head, both the continuously and rotationally grazed fields suffered to some extent from heavy use. The detrimental effects were more pronounced in the continuously grazed pasture. Western wheatgrass was the only primary species that did as well under continuous (27% basal area decrease) as under rotational grazing (26% basal area decrease).

At the rate of 30 acres per head,the vegetation responded even more in favor of the rotated fields. The main forage species, including both blue grama grass, needleandthread, Junegrass, and western wheatgrass, did better under rotational use.

Under both rates there was a marked increase in Sandbergh's bluegrass which is sometimes considered a range weed.

At the 20 acre rate, there was no significant difference in the gains made by the cows nor in the weaning weights of the calves. At the 30 acre rate, however, the average weaning weight of calves in the rotated fields was significantly lower than on the continuously grazed areas. The average gains of the cows under the two systems of grazing at the 30 acre rate were identical. One factor which may have affected adversely the response of the animals in the rotated fields was the small size of the pastures; they were only 66.6 and 100 acres, while the continuous fields were 200 and 300 acres. The cattle in the small fields were restless and did much walking along fence lines.

Clipping studies on grazed fields in 1949 (two pasture rotation versus continuous grazing - April 25 to October 24) showed a 12% increase in forage production in favor of continuous grazing. At the same time, plots were clipped in an exclosure to simulate the actual livestock rotation experiment. The clipping studies showed that rotational grazing produced 10% more forage than the continuously grazed plots.

It may be concluded that conservative continuous grazing in the region concerned is the most practical method of pasture use.

Hudspeth, Ernest. 1962. Cooperation Earned an Increase. Journal of Range Management, 15(2):103-105.

In 1956 and 1957 we put 75 percent of the cattle on Camp Creek. In 1958 we divided them equally between Camp Creek and Dean Creek. We were on the way to our original goal, rest-rotation grazing.

Since the completion of the fences, it has been our practice to defer one unit each year on each allotment. The results are very gratifying. The Forest Service has several transects on each range. They read these on approximately the same dates each year and by so doing have taken the guess work out of range appraisal. Rest-rotation grazing has improved range condition on every study plot. I believe that if we had practiced this method of grazing, beginning in the early 1930's, Dean Creek would have carried the 450 head without the addition of Camp Creek.

All this fencing cost approximately $8,500. That doesn't include a lot of ignorant labor by the permittees, nor does it include depreciation on the jeeps and cats that were used. I imagine that the overall cost was nearly $10,000.

Since we have our two allotments divided into three units each, it is possible to defer one unit for two years should any sore spots develop. The Forest Service has been very cooperative, not only in advice but by seeding some logging roads. In October of this year they fertilized and seeded two hundred acres on Camp Creek. This two hundred acres is on a poor type of soil, so we are all anxious to see the result of fertilization. Of course, the unit containing this seeding project will be deferred for one and maybe two years.

We now have complete control over our range, with the exception of large herds of deer and elk. They concentrate each year on deferred units. In some cases they take fifty percent of the forage, but maybe there is a bright spot there, as it makes better relations between the sportsmen and the stockmen.

Now for the payoff of our labors. Since we have been in a position to practice rest-rotation grazing, our calves are forty pounds heavier and our cows are carrying much more flesh in the fall. To go back to the above mentioned cost of fencing, forty pounds a calf on 400 calves adds up to 16,000 pounds at 25¢ a pound, or $4,000 a year. That, added to the extra flesh the cows are carrying would probably make $5,000 a year that we have gained. Therefore, we retired the cost of fencing, water development, etc., in two years. In addition, and I would like to boast a little here, I believe that we are one of the very few associations in Oregon that was granted a ten percent increase in our grazing permits. This ten percent is temporary, but I am sure that by practicing the present method of grazing it will become preference with perhaps another five or ten percent increase in the next five years. I feel sure that this increase was justified due to the up trend of the ranges. This ten percent increase made us real happy; because, as I mentioned before, we were not assured of any increase when we accepted Camp Creek in 1955.

Hyder, Donald N., and W. A. Sawyer. 1951. Rotation-deferred grazing as compared to season-long grazing on sagebrush-bunchgrass ranges in Oregon. Jour. Range Mgt. 4(1):30-34.

A study was initiated to determine the practicality of rotation-deferred grazing on semi-desert sagebrush-bunchgrass range in Oregon. It is a summer range utilized by cattle, and this report summarizes 11 years of records (1938-48, inclusive) and compares the results with those obtained on range grazed season-long.

In this study, four ranges were used, located some 40 miles west of Burns in southeastern Oregon on generally rolling lands. Big sagebrush (Artemisia tridentada) was the dominant shrub and juniper (Juniperus spp.) occurred in varying abundance. Bluebunch wheatgrass (Agropyron spicatum) and Idaho fescue (Festuca idahoensis) were the best forage grasses. Sandberg bluegrass (Poa sandbergii), although producing the greatest forage density was of secondary value. The pastures were approximately 2,100 acres each.

Three of the ranges were grazed under a rotation system. The six-year rotation period included two years of consecutive spring use, followed by one year of partial deferment, two years of full deferment, and one year of partial deferment. The three grazing periods were of approximately equal length in number of days. Since the growing season usually begins April 1 and ends June 30, the partial deferment period of grazing was essentially full deferment.

The fourth range was grazed continuously throughout the grazing season--from approximately May 1 to October 1. The stocking rate of 10 to 12 surface acres per animal unit month was approximately the same under both systems of grazing and from year to year.

The breeding cow herds were balanced as to age, size, grade, condition, calving date, and weight performance on summer range. Permanent plots located on a 10 by 20 chain grid throughout the ranges were used for square-foot density estimates during 1938, 1944, and 1948. Utilization data were taken yearly on each range after grazing was concluded. The experiments did not incorporate randomnization or replication, so statistical analysis could not be applied to the data.

Cattle weights on the season-long range showed less than half the variation between years during the first grazing period, about the same variation during the second period, and nearly twice the variation during the third grazing period as on the rotation ranges. Also, cows on the season-long range gained 23 pounds more per animal during the first grazing period, 6 pounds less during the second grazing period, and lost 8 pounds more during the third grazing period. There was an average annual advantage in weight gain of 9 pounds per cow for the season-long range.

Utilization records permitted the division of each range into lightly, properly, and heavily grazed areas. The proportion of each of these use divisions indicated the distribution of grazing in that range. Fifty-six percent of the rotation ranges was properly utilized as compared with 39 percent of the season-long range. The heavily utilized areas included 26 percent of the rotation and 37 percent of the season-long ranges. There was also a smaller percentage of the rotation ranges lightly grazed--18 percent as against 23 percent on season-long ranges. Also grazing was more evenly distributed in each range under rotation than under season-long grazing. During the study period the season-long range was overutilized by an average of 20 percent whereas the rotation ranges were overutilized by 10, 12, and 14 percent.

The vegetation on the season-long range made a net increase in density of 22 percent as compared with an average increase of 20 percent on the rotation ranges. Of the 22 percent increase in vegetal density on the season-long range, almost 19 percent were grasses, 1 percent shrubs, and 2.5 percent forbs. Of the 20 percent increase on the rotation ranges, 11 percent were grasses, 1 percent shrubs, and 8 percent forbs.

Season-long grazing permitted the greatest increase in forage production.

The increase in density of the two primary forage species was 2.4 percent under season-long grazing. This was more than twice the increase, 1.1 percent under rotation grazing.

The increase in Sandberg bluegrass of 13 percent under season-long grazing as compared with 7.9 percent under rotation grazing, may also indicate greater increase in forage production on the season-long range, but primarily indicates retrogression.

Trends in forage production were depressed following two years of consecutive spring use. Apparently the combination of two years of consecutive spring grazing, and close use during the growing season, offset the advantages gained through deferment as shown by livestock gains and losses.

Apparently the difference between the rotation ranges was primarily one of changes in plant vigor and size rather than in number of plants. Concentration of grazing on a single range for most of the growing season, seriously restricted regrowth of the forage, and storage of carbohydrates for the maintenance of plant vigor.

In the use of a rotation grazing system the authors believe that attention should be directed to plant vigor rather than seed production. Such management will also result in larger seed crops.

Jardine, J. T. 1912. Range Improvement and Improved Methods of Handling Stock in National Forests. Proc. Soc. Amer. For. VII:160-167.

Success in improving forage conditions depends largely upon protecting the best forage plants already present sufficient to secure natural reseeding and reproduction of those species. To accomplish this end and at the same time utilize the forage to the fullest possible extent, it is necessary to know the absolute requirements of the vegetation we wish to reproduce, and then adjust grazing so as to meet those requirements which must, consciously or unconsciously, be acknowledged in any successful system of grazing.

A very intensive study was undertaken to develop such a system of grazing upon high mountain range, which is the most difficult type of range to maintain in condition of maximum productivity, due to short growing season, low temperature, and excessive demand for such range. The essential points determined were:

1. On badly overgrazed areas, where herbage has been seriously weakened by continuous early grazing, at least two and in some cases more than two seasons of protection are necessary before a normal crop of seed is produced.

2. That even on our highest ranges the seed crop is practically matured by September 1, while the grazing season lasts ordinarily to September 15 or October 1.

3. After seed maturity the air-cured forage is palatable and nutritious and so far as reproduction is concerned, it is better to utilize this forage by close grazing than to leave it ungrazed, as the grazing aids in scattering the seed and trampling it into the ground.

4. For the two seasons following the production of a good crop of seed it is essential to graze only in the late fall, and then carefully and only moderately heavy, due to the fact that the newly established seedlings are readily injured by trampling. Besides additional seed is thereby matured to insure abundant reproduction.

From these data can be deduced two principles which are the basis of judiciously deciding periods of grazing. First, that it is impossible to keep a range in condition of maximum productivity if it is close grazed during the first half of the grazing season year after year. Such practice gradually weakened the plant constitution by preventing the development and storage of the necessary amount of reserve food. Second, where sufficient permanent watering places exist, it is possible to work out a rotation system of grazing which will not only avoid impoverishing the plant constitutions, but will result in occasional natural reseeding--both without loss of forage utilization any year. On one forest such a rotation system was successfully practiced on ten sheep allotments last year. The principles are applicable everywhere and are gradually being applied.

In proposing any change in the existing methods of handling the stock after they are on the range, it is necessary to keep in mind its effect upon the vegetation, effect upon the animal, and its practicability from the standpoint of the stockman. The vegetation and the animals again are living organisms having inherent requirements and characteristics of life. A thorough understanding of these natural forces as they exist under range conditions, in conjunction with a first-hand knowledge of handling stock, is the best foundation for building up an efficient system or systems of handling. To facilitate such a study for sheep, a coyote-proof pasture, including 2560 acres of typical mountain range, was inclosed. For five successive seasons a band of sheep has been grazed in the inclosure, free from annoyance of any kind. During this period a careful study has been made of the actions of the sheep, growth of sheep, loss of sheep, to some extent wool growth, carrying capacity of range, and cost of handling under this approximately ideal system, as compared with results on corresponding points under existing systems of handling on the open range. This study necessitated several years of test, but based upon the data collected, it is now possible to safely state to sheepmen that if the sheep are kept constantly on the range instead of being driven back and forth to and from a central camp; if allowed free, quiet, open grazing rather than close herding and worry by dogs; intermittent use of areas instead of constant use until the vegetation is eaten into the ground, the result will be a five to ten pound increase in the weight per head of sheep; a smaller number of unmarketable "dogie" sheep; increased wool growth and an increase in carrying capacity of range of from 10 percent to 50 percent, depending upon the intensity of bad management on previous occasions. A similar study has been in progress two years to try and improve existing methods of handling ewes during the lambing period.

That there is possibility of increasing the carrying capacity of range as well as possibility of increasing the annual crop of sheep, their weight and wool growth is evidenced by the fact that at present the lamb crop varies in any one year from 60 percent to 115 percent of the total ewes, with an approximate average of 75 to 80 percent; the approximate variation in the weight of lambs of the same age and breeding is 25 pounds; the approximate variation in wool crop is from 5 pounds to 11 pounds, and there is a variation of as much as 35 percent in the amount of range required per head of sheep under different herders. That improvement along these lines can be brought about and is being brought about is evidenced by the following results cited from one forest. During the season of 1910-1911 the number of sheep on the Madison Forest was increased from 90,000 to 99,000 on the same range. The supervisor attributed this increase almost wholly to the fact that 50 percent of the sheep are now never returned to a camp at night and are rarely molested by herders or dogs during the day. Formerly they were driven back and forth to and from camp and were herded in the true sense of the word. The lambs from bands handled in the improved way were eight pounds heavier and sold for $1 per head more than lambs of the same age and breeding belonging to the same company, but herded on range outside the forest.

Jardine, J. T. 1915. Improvement and Management of Native Pastures in the West. USDA, Yearbook of Agriculture - 1915, pages 299-310.

For many years in the West there was room for the expansion of the range stock industry. Large areas of unused grazing lands awaited the coming of the stockman. Only part of the pasturage which nature had provided in such seeming abundance was utilized by the herds which grazed in the western country. But this is no longer the case. From the desert to the line of perpetual snow there is now little unused range. Grazing, too, has in most cases been unrestricted, with consequent injury to the forage growth. This has gone on until it is evident that, to maintain the production of even the present number of livestock under the range industry, run-down ranges must be improved and an efficient system of native pasture management worked out. In short, it will be necessary not only to build up the range lands, but to keep them at their maximum carrying capacity once that is done. There is urgent call for such measures now, but this call will become steadily stronger as settlement advances into the stock country and range pasture is needed for the farm herd to supplement the pasturage and feed crops produced on the cultivated land.

Data collected by the Kansas Agricultural Experiment Station show that in that State in 1910 the average area of grazing land required per steer was 3.80 acres and in 1914, 6.55 acres, an increase of 72 percent. Along with this go a corresponding increase of 31 percent in the pasture rent per steer and a decrease of 24 percent on the income per acre. Kansas has 2 acres of pasture land to every 3 acres cultivated and cropped. Though largely unsuited for cultivation, these pasture lands have reached a total valuation of approximately $400,000,000 for grazing purposes. This figure gives some idea of how important, from a money standpoint, is the problem of bringing the lands back to their former degree of usefulness and keeping them there.

The more common practice on private lands, however, has been to put on all the stock that the range would carry and turn them off in fair to good condition, in the belief that if the stock came off in satisfactory shape the range was not overstocked or injured. This is true, provided the season of grazing is limited so as to give the vegetation a chance to do more than merely produce a few leaves, which are eaten as soon as they are long enough to crop. It is not true if the stock are turned on the pasture lands as soon as there is enough green food for them to live on and kept there, to the apparent capacity of the pasture, as long as they can remain in fairly good condition. The fact that this has been the method followed accounts for the decrease in carrying capacity of many private pastures, when the owners believed that the lands were not overstocked. Animals which are allowed to graze the green feed of the choice forage plants nearly as fast as it grows may, for the time being, get enough to eat, but to rob the plants

continuously of this foliage robs them also of their laboratory for manufacturing plant food, and they are gradually starved out of existence. The change perhaps is not noticeable during any one year, but in a period of 5 or more years the better forage plants are greatly reduced, if not killed out, and their place taken by less desirable grasses and weeds.

The condition of the stock, therefore, is not in itself a safe way to judge whether a range is overstocked or not.

When the season of grazing that will give the vegetation the greatest chance to grow, consistent with the profitable handling of the stock, is decided upon, then, and not until then, can the number of stock a given pasture will carry be consistently estimated. It should be determined finally by careful observation of the range, not the stock, over a period of from 3 to 5 years.

Where the vegetation was badly overgrazed at the beginning it was found that two seasons of protection until after seed maturity was necessary before the original plants became vigorous enough to produce a crop of fertile seed. In such cases it took four years to accomplish what was accomplished in two years where the original vegetation was vigorous enough to produce a crop of fertile seed the first season of protection.

A study was made to determine the improvement in vegetation secured under this plan of management as compared with similar range grazed throughout the season each year, and also with fenced areas not grazed at all. At the end of the third year it was found that the reproduction from seed was five and one-half times greater on the lands grazed after seed maturity each of the three seasons than on the areas totally protected against grazing while the reproduction of good forage species was much greater.

It was found that establishment of seedlings depends very largely upon the thoroughness with which the seed is planted.

Following the Oregon experiments the system of deferred grazing has been tested out elsewhere on both cattle and sheep ranges, and both practically and experimentally, with results that confirm those secured in Oregon. In a three-years' test on early summer overgrazed sheep range in Wyoming, the total vegetation on range grazed each year after seed maturity increased at least 100 percent, and of this at the end of three years 80 percent was made up of the best forage plants. On an adjoining area protected against grazing for three seasons the total vegetation increased 80 percent, while the proportion of desirable forage plants at the end of the test was only about 25 percent. Adjoining range, grazed season-long each of the three years, had only one-half as much total vegetation as the area grazed each year after seed maturity, not more than 22 percent of which was made up of the best forage plants.

Jardine, James T. and Mark Anderson. 1919. Range Management on the National Forests. USDA Bul. No. 790. 98 pp. illus.

A system of deferred and rotation grazing is intended to promote natural reseeding.

The following are some of the principles developed in investigations on the relation of grazing to growth and reproduction of forage plants (Sampson, 1914):

1. Removal of the herbage year after year during the early part of the growing season weakens the plants, delays the resumption of growth, advances the time of maturity, and decreases the seed production and the fertility of the seed.

2. Under the practice of yearlong or season-long grazing, the growth of the plants and seed production are seriously interfered with. A range so used when stocked to its full capacity, finally becomes denuded.

3. Grazing after seed maturity in no way interferes with flower-stalk production. As much fertile seed is produced as where the vegetation is protected from grazing during the whole of the year.

4. Deferred grazing (grazing after seed maturity) insures the planting of the seed crop and the permanent establishment of seedling plants without sacrificing the season's forage or establishing a fire hazard.

5. Deferred grazing can be applied wherever the vegetation remains palatable after seed maturity and produces a seed crop, provided ample water facilities for stock exist or may be developed.

6. Yearlong protection against grazing of the range favors plant growth and seed production, but does not insure the planting of the seed. Moreover, it is impractical, because of the entire loss of the forage crop and the fire danger resulting from the accumulation of inflammable material.

Excessive damage from grazing during the early part of the growing period is largely avoided if grazing does not begin until the main forage grasses are in the boot. But between this opening date and the time of seed maturity of these same plants there is a period of about six weeks, during which continuous grazing year after year on a fully stocked range would materially weaken the forage plants and result in range deterioration.

The system of deferred and rotation grazing aims to minimize the injury from grazing during this period (1) by having each portion of the range

bear its share of the early grazing and (2) by protecting each portion of the range in its turn until after seed maturity, so that the main forage plants will regain their vigor and reproduce either from seed or vegetatively.

The number of years necessary or the number advisable depends upon the extent to which the vegetation has been killed out and the soil depleted in fertility (Sampson, 1914) and must be decided in the individual case after a careful examination of the vegetation. Deferred grazing should be continued until there is satisfactory reproduction of the principal forage species.

On ranges within the National Forests the two main difficulties are: (1) great variation in character of forage and growing season, due to variation in altitude and exposure; (2) lack of fences or other means of controlling the stock, especially cattle.

The variation in season of growth between the Forest boundary and the mountain top and high basins is so great that inclusion of the whole stretch of country in one grazing period without control of stock between the boundary and the skyline is ineffective.

The first main division between spring and summer range, however, is essential and should be warranted, as only large areas are involved. It is worth thinking about and planning for, even if adequate control of stock cannot be secured at once.

Johnson, W. M. 1965. Rotation, Rest-Rotation, and Season-Long Grazing on a Mountain Range in Wyoming. USDA, Forest Service, Rky. Mtn. F&R Exp. Sta., Res. Paper RM-14. 16 pp. illus.

A four year study (1958 through 1961) was conducted on the Medicine Bow National Forest in Wyoming to evaluate three methods of management in relation to their effect on patterns of utilization on upland and bottom areas, and accompanying changes in the vegetation.

Different methods of management were compared on three allotments. The North Pasture allotment (15,548 usable acres) was divided into four units about equal in grazing capacity for rest-rotation management. Three units were grazed each season, while the fourth was left ungrazed for that season:

	1958	1959	1960	1961
June 1 - July 16	1	2	3	4
July 17 - August 31	2	3	4	1
Sept. 1 - October 15	3	4	1	2
Not grazed	4	1	2	3

The Green Mountain allotment (8,974 usable acres) was also divided into four units, but all units were grazed each year in a simple four pasture rotation system:

	1958	1959	1960	1961
June 1 - July 4	2	3	4	1
July 5 - August 7	3	4	1	2
Aug. 8 - Sept. 10	4	1	2	3
Sept. 11 - Oct. 15	1	2	3	4

The Lodgepole allotment was continued under season-long management, and used as a check to help evaluate changes in utilization and vegetation on the other two allotments.

How the system of management influences utilization was studied by comparing the use of the types during the 1956-57 period ("pre-treatment"), when all allotments were grazed season-long, with the utilization during the 1958-61 period ("treatment"), when the Lodgepole allotment was grazed season-long, and the North Pasture and Green Mountain allotments were grazed under rotation plans.

There was no significant change in utilization on the Lodgepole allotment, which was grazed season-long during both the pretreatment and treatment periods.

Rotation management on the Green Mountain allotment during 1958-61 reduced average utilization on grassland types slightly below the pretreatment level, but the reduction probably was not of practical

significance. On the meadows, however, utilization during the rotation period was reduced from 41 to 16 percent.

Utilization during the rest-rotation period of management on the North Pasture allotment was about half that received during pretreatment period of season-long grazing. The largest reduction in use (10.2 percent) was measured on the meadow types, and the least (3.8 percent) on the grassland types. There was no real change in the pattern of grazing on the different types of vegetation, but rather a general decrease over all types.

Under rest-rotation management, the cattle were more equally distributed.

The time of year that an area was grazed had little effect on the intensity of utilization on grassland types.

From these studies it would appear that grazing use of different vegetation types and of individual species of plants is related more to the needs and preference of the animal than to the time of year the range is grazed.

Plant cover did change during the period of study:

	Original 1958	Change* 1962
Lodgepole (season-long grazing)		
Wet bottoms	78	+ 5
Grasslands	43	+ 4
Green Mountain (rotation grazing)		
Wet bottoms	77	+10
Grasslands	60	- 1
North Pasture (rest-rotation grazing)		
Wet bottoms	76	+15
Dry bottoms	61	+20
Grasslands	46	+12
Mixed shrub	29	+13

*In number of hits per 100-foot transect.

Results of this study indicate that either rotation or rest-rotation systems of management can benefit cattle ranges. The most striking result is reduced utilization without any reduction in the number of animals grazed. Reasons for reduced utilization without reduction in livestock numbers have not been fully determined. Several factors may be involved: (1) increased total production of herbage because of increased plant vigor; (2) growth and production of herbage are allowed to get "ahead of the cattle" each year on all but one unit in either system of management; and (3) the previous year's regrowth after grazing is mixed with the current year's growth, which provides more bulk in the diet.

Keng, E. B. and Leo B. Merrill. 1960. Deferred Rotation Grazing Does Pay Dividends. Sheep and Goat Raiser, June 1960, pages 12-13, illus.

A 25-percent increase in range condition and forage production was obtained from a four-pasture deferred rotation system of grazing on the Sonora Experiment Station, as compared to continuous yearlong grazing with the same number of livestock.

In the deferred rotation system on the Sonora Station the grazing unit was divided into four pastures of about equal grazing capacity. One pasture is rested each four months and the other three are grazed. At the end of four months, the livestock in one pasture are moved, and a different pasture is deferred the next four months. Thus, each pasture is grazed 12 months, then rested four months. The rest periods fall during a different season each year.

The three pasture system operates in about the same way except that each pasture is rested three months and grazed six months. This delays the rest period three months each succeeding year. The pasture resting March, April and May the first year, rests December, January and February the second year, etc.

The two-pasture or South African Switchback system places all of the animals in pasture one for three months, then on pasture two for six months, back to pasture one for six months, then to pasture two for three months, etc.

In order to determine the adaptability of ranches to a deferred rotation grazing system, a study was made on 100 ranches selected at random in the Edwards Plateau Soil Conservation District to: (1) determine the relative number of ranches which could adopt one of three deferred rotation grazing systems as a part of their conservation plans without any additional cost, (2) determine the cost involved on those ranches which would not presently fit into a system, and (3) determine the number of ranches which could not adopt any of the three systems without excessive fencing and watering costs.

Over half of the 100 ranches studied can with no additional cost establish a four-pasture deferred rotation grazing system, while 22 ranches can establish such a system at a cost of one or two miles of fence. Eight of the ranches can establish a three-pasture system with no cost, while six would require additional fence. Eight can establish the South African Switchback two-pasture system with present fencing, and two more would require one or two miles of additional fence. Two ranches would not fit into any of the three systems. These were small ranches with one large pasture and one or more small traps.

Lang, R. and O. K. Barnes. 1942. Range Forage Production in Relation to Time and Frequency of Harvesting. University of Wyoming Agr. Exp. Sta. Bull. No. 253. p. 32.

Southeastern Wyoming is on the edge of the Great Plains region. The topography is level to gently rolling and the mean annual rainfall is approximately 14 inches.

The vegetation is quite typical of the Great Plains area. On the flat lands the dominant grass is blue grama (Bouteloua gracilis). Mixed with the blue grama in varying proportions is buffalograss (Buchloe dactyloides) which is the second dominant. Western wheatgrass (Agropyron smithii), needleandthread grass (Stipa comata), Sandberg's bluegrass (Poa secunda), and Junegrass (Koeleria cristata) are found in scattered stands with the above-named dominants.

Clipping experiments carried on at the Archer Field Station in southeastern Wyoming show that the short grasses yield more when harvested frequently at ground or crown level than they do when protected during the growing season and harvested after growth has ceased. This was true even on plots which had been harvested in this manner for two years with no apparent decrease in the density of perennial grasses.

Midgrasses were found to yield significantly higher under protection and harvesting at the end of the growing season than under frequent clipping, just the opposite reaction to that exhibited by the short grasses.

Annual forbs made the same response as the midgrasses, that is, lower yield under frequent clipping. Perennial forbs reacted in the same manner as the short grasses in giving a higher yield under frequent clipping.

The preliminary results obtained by these clipping experiments indicate that on a short grass range a system of grazing which would utilize some of the forage during June and July and the remainder at the end of the growing season would give a greater amount of more palatable forage than a system which deferred grazing until the end of the growing season.

Possibly a system of intensive rotation grazing wherein units of the pasture or range were utilized near to the maximum each month would produce a maximum amount of forage from the short grass areas.

The basal density of the short grasses was not observed to have been lowered after one year of frequent clipping. However, the density of these grasses after the second year of frequent clipping showed a slight decline.

If one expected to get the maximum amount of forage from a midgrass range it would be necessary to defer it until the end of the growing season. However, these grasses become relatively unpalatable when they mature as well as being high in fiber and low in protein. It is possible that the smaller amount received by frequent grazing would offset in quality the extra quantity received by end-of-season grazing.

Laycock, William A. 1961. Improve Your Range by Heavy Fall Grazing. Reprinted from the National Wool Grower, June 1961.

Spring rest with heavy fall grazing by sheep resulted in less sagebrush and more grass and other herbage in studies on native range at the U.S. Sheep Experiment Station near Dubois, Idaho.

Starting in 1924, one 80-acre range unit at the Sheep Station was grazed heavily in the spring and lightly in the fall, while an adjacent unit was grazed heavily in the fall only. The spring-fall grazed area deteriorated and by 1949 was in poor condition, with an abundance of sagebrush and a reduced amount of grasses and forbs. In contrast, the fall-grazed unit remained in good condition, with an open stand of sagebrush and an abundance of grasses and forbs.

In 1950, both units were cross-fenced. The former grazing treatments were reversed in one-half of each but were continued in the other half. In addition, grazing was restricted to spring only and to fall only, and rates were increased slightly to 40 sheep-days per acre in the spring and 60 sheep days in the fall. These are considered heavy spring and fall rates in this area.

Conditions did not change much where grazing was continued essentially as in the past. The spring-grazed area was still in poor condition in 1957, and the fall-grazed area was still in good condition. However, changes were very evident in the units where the grazing treatments had been switched in 1950. Range condition improved from poor to fair from 1950 to 1957 in the new fall-grazed unit. Heavy fall grazing considerably increased grass production and decreased sagebrush.

The area changed to spring grazing in 1950 deteriorated from good to poor condition by 1957. Heavy spring grazing caused the grasses and forbs to decrease and the sagebrush to increase. These changes also could be seen and measured as early as 1953.

Thus, spring deferment and heavy fall grazing improved range condition faster than did complete exclusion from grazing.

What causes the decrease in sagebrush and the increase in grass and forbs? Part of the answer, of course, is that complete rest throughout the spring growing season permits grasses and forbs to maintain maximum vigor.

But sagebrush decreased more under fall grazing than under complete protection, even though neither area was grazed in the spring. The fall grazing evidently damaged the sagebrush but permitted the grass to increase.

Difference in growth habits between sagebrush and grass suggests another reason for their different response to fall grazing. Native grasses and many forbs in the Upper Snake River Plains of Idaho stop growing before July 1. On the other hand, sagebrush and most other shrubs in the area continue their growth until fall.

Sheep seldom eat shrubs in the spring, except perhaps the flowers of bitterbrush. In the fall, however, the sheep do utilize sagebrush and other shrubs.

Leavell, William G. 1960. Improvement of an Eastern Oregon Rangeland Through Grazing Management. Abstracts of papers presented at the 13th Annual Meeting, ASRM, p. 58.

The Skull Creek Unit is located in southeastern Oregon in the Burns BLM District. One of the ten units in the district, it typifies those public domain lands lying between private winter baselands, and National Forest summer rangelands throughout eastern Oregon.

It is a relatively small unit, 60,000 acres in size, and consists generally of sagebrush--bunchgrass types with an intermingling of ponderosa pine and juniper overstory. With an average elevation of 4,800 feet, it has an average precipitation of 12".

Prior to 1935, the area was used by the livestock of adjacent landowners and by large numbers of transient cattle and sheep, with much of the use made immediately after snowmelt. Actual management of the unit began in 1935, under the combined efforts of the Grazing Service and the qualified range users. Dates of use were established between April 1 and October 31. Trespass livestock were largely eliminated. Range users followed a number of range management practices including proper salting, cattle distribution by riding, etc. Still, the unit was rated as being most needful of corrective practices, in the district, in 1951.

A survey of the unit's vegetative resource was made in 1952. This survey indicated that the unit was heavily overstocked and used too early in the season.

The users formed a grazing association in 1953 and beginning with the 1954 grazing season, reduced their grazing use in half, by using the range for half the time with the same number of livestock. Turnout dates were delayed until May 1.

Condition transects, utilization checks, point photographs, personal observations, all indicate that this unit's resources are improving, slowly from 1935 to 1953; but now quite rapidly from 1954 to 1959, with the development and use of the proper range management practices.

Within five years of adjusted grazing use, and a normal frequency of low and high precipitation years, the unit is proving that semi-arid rangelands in eastern Oregon, by the combined efforts of both users and administrators, can and will improve.

Leithead, Horace L. 1960. Grass Management Pays Big Dividends. Jour. Range Mgt. 13(4): 206-210, illus.

An 8,450 acre bunchgrass - sagebrush range on the southern slopes of Badger Mountain in Douglas County, Washington, has been grazed from 7-8 months each year.

Elevation varies from about 1,500 to 2,500 feet and average annual precipitation is approximately 10.6 inches. Grass starts growth about March 20 and matures in early July. Bluebunch wheatgrass produces the bulk of the forage on the ranch and is the basis for the owner's (Howard Sachs) grass management plan.

Prior to management, Sachs removed cattle from spring range when the surface soils had dried to a depth of 4 inches. He never turns stock on the range in the spring until there is enough new grass to supplement the dry grass that is carried over. The pasture used for early spring grazing for many years remained in good condition. Other pastures were all grazed during the period of active plant growth. Bluebunch wheatgrass had died out over much of this range and been replaced by cheatgrass and big sagebrush.

In the fall of 1946, Sachs reduced his breeding of 160 head by 50%, constructed an additional 3½ miles of fence, and planned a rotation-deferred system of grazing. No pasture except the early spring pasture would be grazed at the same time year after year. Pastures that were grazed during the period of active plant growth one year were deferred one and sometimes two succeeding growing seasons. These deferred pastures were grazed in late summer and fall. Cattle were rotated when 50 percent removal of the current year's growth was achieved. Sachs stated that this was all that could be harvested from bluebunch wheatgrass on the ranch if it were to maintain vigor and increase in composition.

In 1956, over a thousand acres were still in such poor condition that Sachs decided it would be more economical to reseed these acres than to restore them through management alone. This called for excluding two pastures for two years. The breeding herd which had gradually been built up from 80 head in 1947 to 151 in 1956 was reduced to 117 head to compensate for this.

During these 11 years (1947-57 inclusive) Sachs realized the following from improved range conditions:

1. Beef production increased from 2.9 pounds to 7.4 pounds per acre (255% increase).

2. Net returns to range improvement and management over this same period jumped from 4 cents to 83 cents per acre.

McIlvain, E. H. and D. A. Savage. 1951. Fourteen-Year Summary of Range Improvement Studies at the U. S. Southern Great Plains Field Station, Woodward, Oklahoma, 1937-1950. USDA, Bureau of Plant Industry, 50 pages, illustrated.

Continuous summer grazing has been compared with 3-division rotation grazing in duplicate pastures at both heavy and moderate stocking rates since spring of 1942. These pastures contained the same acreage and were stocked and handled exactly as were those in the continuous summer grazing studies with one exception. The rotation pastures were divided into 3 equal parts and the steers rotated among divisions at regular intervals. They were rotated at 2-month intervals in 1942; 1-month intervals during the 5 years, 1943-46 and 1948; 15-day intervals in 1947 and 1949; and at 10-day intervals in 1950.

The objective of the study was to develop a method of improving native range by alternate protection and grazing of the forage. This objective has not been accomplished at the end of 9 years, although there is now some evidence from other studies that a system of rotation may be developed which will improve the forage without lowering steer gains per head or per acre.

Rotation grazing at 2-month intervals in 1942 reduced steer gains greatly as compared with continuous use. There was a slight though not a real or statistically significant difference in gains in favor of continuous grazing when the steers were rotated at monthly intervals. Semi-monthly rotation produced gains identical with continuous grazing at the heavy stocking rate, but lower gains under moderate use. Rotation at 10-day intervals in 1950 resulted in a 23-pound advantage in gain per head and a 5-pound advantage in gain per acre at the heavy rate, and equal gains at the moderate rate.

Density of blue grama increased significantly from 1940 to 1949 in the heavily grazed rotations. No other species or class of vegetation showed a statistically significant or real difference.

Despite lack of significance between comparisons of all species or classes of vegetation, except blue grama under heavy rotation grazing, the density studies showed a slight advantage for rotation grazing. The tall grasses, such as sand bluestem, little bluestem, sand lovegrass, and switchgrass, increased most under rotation at both grazing rates, while sand dropseed decreased slightly in density only under rotation grazing. The perennial forbs, most of which are readily eaten by steers, decreased 50 and 67 percent under moderate and heavy continuous use, respectively, and increased 20 and 33 percent under rotation at the respective stocking rates. The invader-type grasses, including sand paspalum, fall witchgrass, and hairy grama, increased most under continuous use which indicated that rotation grazing was slightly beneficial.

The productive tall grasses increased greatly in the "B" divisions of all rotation pastures, indicating an extremely favorable combination of protection and grazing occurred sometime during the period on this division and not on the others.

A 2-division rotation during the summer months gave essentially the same results as reported for the 3-division rotation, i.e. rotation depressed steer gains a few pounds and improved forage production slightly.

A 2-division alternate-year rotation likewise failed to show any real advantage over continuous grazing. This rotation was modified in 1949-50 to provide for alternate spring deferment and summer rotation as needed to protect the vegetation at intervals and keep forage available to cattle at all times. The entire pasture is used continuously during winter and drouth periods. Preliminary results indicate that this system is improving the vegetation without a material decrease in steer gains.

Continuous yearlong grazing represents a conservation practice in this region, since enough forage must be left on the land at the end of the growing season to carry livestock throughout the winter. This results in less injury to vegetation than where pastures are grazed to utilize most forage during summer.

This principle is illustrated by comparing yearlong and summer stocking rates used in these investigations. An average rate of 6 acres per yearling steer was required for proper use of good condition sandy range for the summer 6 months, and only 9 acres for proper yearlong use. Lighter summer use under yearlong grazing, plus 50 percent more land, provided sufficient forage for approximately 90 percent more grazing without injury to the vegetation. Grasses suffered less injury when closely grazed in winter than when similarly grazed during the growing season. However, heavy winter use was also detrimental. It is estimated that grasses can be safely grazed one-fourth to one-third heavier after becoming dormant than they can during the growing season.

An economic factor which favors yearlong grazing with steers is that if steers are annually replaced on the same price market on which they are sold, the stability of the steer business approaches that of the cow operation. Preliminary analyses based on cattle operations in this region indicate that weaner steers, grazed yearlong, are more profitable than cows and calves when cattle prices are at the high 1950 level. It also appears that there is less differential in profits between the two types of operations when cattle prices are low.

Despite apparent advantages to the vegetation from yearlong grazing, a comparison of the 9-year results from the summer and yearlong pastures shows that more gain per acre and more monetary returns were made from moderate summer than from moderate yearlong grazing. However, stockmen operating on a summer-long basis must manage their grass more carefully than if they were grazing yearlong, since grass is more easily injured by overuse during the growing season.

McIlvain, E. H., and D. A. Savage. 1951. Comparisons of continuous and rotational grazing on the Southern Plains Experimental Range. Jour. Range Mgt. 4(1):42-47. illus.

This paper presents experimental results of one form of rotation grazing on the semi-arid rangeland of the southern Great Plains. During the growing season, the animals were rotated at regular or irregular intervals on two or three divisions of a dryland, native range. This rotation plan will be referred to as "divisional rotation." Only an occasional paper reports results of experimental work on "divisional rotation." Many of the studies lack replication and proper controls, and some confound rotation grazing with other factors, such as rate of stocking, breed or species of stock, mowing practices, or fertilization.

The experimental range is located in the northwest portion of Oklahoma near the 100th meridian. During the period of this study --1941 to 1949-- the annual precipitation averaged 26 inches, which is 12 percent above the 77 year average. Seventy percent falls during the six summer months. The normal growing season extends from April 1 to November 1.

The vegetation consisted primarily of sand sagebrush, with an understory of blue grass and sand dropseed. Sand lovegrass, sand bluestem, little bluestem, and switchgrass were the most important tall grasses. Average air-dry forage yield was about 1,300 pounds per acre of which 43 percent was blue grama, 25 percent tall grasses, 15 percent sand dropseed, 10 percent miscellaneous grasses, and 7 percent forbs.

Good grade yearling Hereford steers were used.

Comparisons were made on duplicate pastures where continuous and divisional rotation grazing at moderate and heavy stocking rates were carried out. Each heavily grazed pasture contained 50 acres and was cropped at an average of 4.3 acres per steer. The moderately grazed pastures were 75 acres, cropped at 6.3 acres per head. The rotational pastures were divided into equal parts.

In 1942 the steers were rotated between divisions at two-month intervals, but both vegetation and cattle suffered greatly from the concurrent heavy cropping. Thereafter, the animals were rotated at monthly intervals--except in 1947 when the rotation interval was 15 days--to prevent too heavy grazing on the divisions during the latter part of each period.

The results of the seven-year study show no statistically significant difference between continuous and rotational grazed steer weights at either heavy or moderate rate. But continuous grazing at moderate rate did produce 10 pounds average annual advantage in gain per head. Steer gains under rotation were less than the continuous system in spring and summer cropping, but slightly greater in fall.

The data show no significant vegetative difference between the two systems of grazing. However, there was a statistically significant increase in density of blue grama due to rotation at the heavy rate. The tall grasses increased more under rotation at both grazing rates, while sand dropseed decreased slightly in density. The class of miscellaneous mid-grasses increased most under continuous grazing. According to some authorities, sand paspalum, fall witchgrass, and hairy grama are "increasers" under heavy use. If this be true, then rotation grazing benefits the miscellaneous mid-grasses more than continuous grazing.

Apparently the detrimental effects of heavy stocking on two-thirds of the pasture balances the beneficial effects of deferment of one-third. Cattle gains are less during spring and summer because the animals are denied access to each plant species when it is most palatable and nutritious. Also the cattle make less gain while becoming accustomed to the new pasture. They usually spend some time trailing around the fence lines. Two-thirds of the rotation pasture was being more heavily grazed than the continuously cropped pasture, hence only one-third of the area would receive full benefit of seeding.

Evidence indicates the need of a reduction in stocking rate rather than in the rotation of the same number of stock to effect improvement through deferment.

McMillen, W. N., and O. Williams. 1944. Range and Pasture Studies and Grazing Recommendations for Southern Great Plains. Panhandle Agr. Exp. Sta. (Oklahoma) Bull. 67, 48 pp.

Several million acres of native grassland are utilized for livestock production in the Southern High Plains area, which includes southwestern Kansas, southeastern Colorado, the Oklahoma Panhandle, northwestern Texas, and northeastern New Mexico.

The altitude in this area varies from approximately 2,300 feet in the southeast to approximately 5,000 feet in the northwest, with a drop of 4 to 16 feet per mile on the more level uplands.

Climatic conditions, as summarized by Finnell (1932), prevailing in this general area are of a semi-arid nature with an average annual precipitation of approximately 17 inches, about 80% of which occurs during the spring and summer months. The extreme range in mean daily temperature is from 98.4°F to 4.7°F. The average annual evaporation from open tanks in this area is approximately 66 inches. The average growing season is about 188 days in length with the last killing frost in the spring occurring on the average about April 17 and the first killing frost in the fall occurring about October 23.

The predominating soil type on the more level upland areas is a moderately heavy silt loam, with a depth ranging from about 6 to 24 inches. The more rolling and broken areas usually have a much shallower soil varying from a heavy fine-textured type to areas of sandy loam and calcareous or rocky out-crops.

The predominating grasses in this general area are buffalo (Buchloe dactyloides) and blue grama (Bouteloua gracilis), which are found especially on the heavier upland soils. In addition to these two species, on the sandy upland soils the bluestem (Andropogon spp.) and sagebrush (Artemisia filifolia) are commonly found, together with limited amounts of sideoats grama (Bouteloua curtipendula), sand dropseed (Sporobolus cryptandrus), and other species.

According to the best information available, the carrying capacity of pastures in this area has been reduced considerably in recent years because of the high rate of stocking and periods of extremely dry weather with accompanying dust storms.

Frequent clipping of blue grama and buffalograss for five years produced a larger per acre yield of dry matter, protein, carotene, ash, calcium, and phosphorus than more infrequent clipping. The density and volume of production of buffalograss was apparently unaffected by frequent clipping while frequent and severe clipping of blue grama thinned the stand, weakened the plants, and decidedly decreased the volume of production.

Attempts have been made in recent years to increase the yield of grasses on much of the range land through changes in the grazing plan, mechanical treatments, or other methods. It is desirable to find out which of these methods will be most effective in promoting the growth of additional grasses and also the effect of different treatments on the quality of the vegetation produced.

Observations suggest that buffalograss can stand early and heavy clipping for five years under conditions similar to those in this experiment, but early and heavy grazing will tend to lower the yield and decrease the density of blue grama. From these results on nutrient yields, it seems that it might be advisable to fully utilize both grasses early in the season to get a higher yield of carotene, protein, and phosphorus. Special attention must be given blue grama to prevent overgrazing, especially early in the grazing season. Canfield (1939) found that persistent grazing of black grama for ten years will practically destroy the stand. It appears that the same might happen with blue grama here.

Yearling Hereford steers or heifers were turned into the pasture in the spring as early as the grass was ready for grazing. Five Holstein heifers were used in 1943. The cattle were weighed for three days in succession to determine the initial weight and were weighed at approximate intervals of two weeks until most of the grass was grazed to a height of about two inches. They were then weighed three days in succession to determine the final weight. Sheep were put in the pasture when more complete utilization of weeds, particularly Russian thistle, was desirable.

The five-year summary reveals that yearling Herefords and Holsteins grazing the pasture for an average of 130 days for five seasons made an average daily gain of 1.19 pounds and produced a yearly average of 32.1 pounds of beef per acre.

The average daily gain for June was 1.49 pounds compared to .73 pound for August. When the herbage contained 13 to 25% crude protein (dry basis) and 10 to 37 milligrams of carotene per 100 grams in June, gains were high. As the protein dropped to 6 to 8% and carotene to 3 to 6 milligrams in August, average livestock gains were corresponding low. These figures indicate that gains are related to chemical composition.

The rather universal practice on ranch units of using the upland short grass pastures for summer grazing and the rougher broken areas, which usually contain taller grass and sagebrush, for winter grazing seem to be best for this area. This is based, however, on the idea that protection from adverse weather conditions is needed during the winter and that the sagebrush and tall grasses are more readily available for grazing during snow storms than are the shorter grasses. All of the grasses are ordinarily much more palatable during the early part of the growing season and are usually much higher in feed nutrients at this time. Buffalograss retains the feed nutrients during the winter months better than most other grasses, as is discussed elsewhere in this bulletin.

Continuous and rotation grazing were not greatly different in respect to steer gains or effects on vegetation in these tests. Therefore, rotation grazing cannot be recommended over continuous grazing as an improved management practice on the sand sagebrush ranges of the Southern Great Plains.

Results from resting grass are quite different from the rotation system previously discussed. Spring or summer-long deferment of grass is an extremely beneficial range improvement practice so long as the stocking rate on an entire ranch unit is reduced or extra feed provided so that overgrazing does not occur simultaneously on another pasture. Whenever possible, spring or summer-long deferment should be combined with brush control to eliminate both grazing pressure and brush competition. In this manner, stockmen can greatly improve the over-all production of their range and carry more livestock later.

Martin, S. Clark. 1966. The Santa Rita Experimental Range. A Center for Research on Improvement and Management of Semidesert Rangelands. U.S.D.A., Forest Service, Rocky Mountain Forest and Range Experiment Station, Research Paper RM-2, 24 pages, illus.

The Santa Rita Experimental Range, 30 miles south of Tucson, Arizona, is maintained by the Forest Service, U. S. Department of Agriculture, for research on semidesert ranges grazed by cattle. The 50,000-acre Experimental Range was established in 1903. Average yearly rainfall increases with elevation from 10 inches at 2,900 feet to almost 20 inches at 4,300 feet. About 60 percent of the rain comes between July 1 and September 30. No effective rainfall is expected in April, May, or June.

The perennial vegetation is dominated by mesquite, cactus, and other shrubs. Mesquite, burroweed, and cholla cactus reach their highest average densities between 3,200 and 3,600 feet elevation; mesquite and pricklypear cactus are major species even above 4,000 feet. Other shrubs, including Acacia, Mimosa, and Calliandra, make up only 21 percent of the shrub cover below 3,200 feet but comprise 65 percent of the shrub cover above 4,000 feet. The abundance of perennial grasses increases with rainfall and elevation. The species composition of the perennial grass stand also changes with elevation and rainfall. The tall three-awns are common at all elevations. Santa Rita threeawn, Arizona cottontop, and Rothrock grama are major species at the middle and lower elevations but are minor species above 4,000 feet. Bush muhly makes up a greater part of the grass stand at the lower than at the middle elevations, and is scarce at the upper elevations. Other gramas including black, sideoats, slender, sprucetop, and hairy, make up over 60 percent of the stand at the upper elevations and are relatively scarce at the middle and lower elevations.

The objective is to learn how to attain maximum sustained forage and beef production on semidesert range with reasonable costs. The research program includes many kinds of studies. Most important of all is research to develop grazing practices that meet the long-time needs of the forage plants and the soil, as well as the immediate needs of the cattle and the rancher.

Perhaps the most persistent factor that contributes to the improvement or decline of semidesert ranges is the grazing use. The season of grazing, the number of animals, and, to some extent, the intensity and distribution of grazing use can be controlled. Without such control, cattle graze forage from the best forage plants on the most accessible parts of the range 365 days per year. The natural end result of this process is that the most productive parts of the range eventually become the least productive. By forcing cattle to graze less on favorite parts of the range and more in areas where they ordinarily would not go, a higher percentage of the total forage crop can be harvested without

damage to the most accessible areas. Improved grazing management probably is the most effective and economical tool for improving the productivity of semidesert cattle ranges.

Moderate grazing maintains range productivity. Grazing too closely or too frequently weakens perennial grass plants and cuts down seed production. Approximate standards of proper use developed for several important perennial grasses on the Santa Rita are as follows: 40 percent of the herbage produced by perennial grasses is used each year. This level of use has been achieved if 46 percent of the perennial grass plants remain ungrazed when effective summer rains introduce the new forage year. This level of use also leaves an appreciable quantity of herbage on the ground.

Moderate to heavy yearlong grazing reduces number of seedlings of taller grasses. Seedlings or sets of 11 perennial grass species studies for 17 years became established every year. Species were black, hairy, sideoats, Rothrock, sprucetop, and slender gramas, Arizona cottontop, mesa threeawn, tanglehead, wolftail, and curlymesquite. More seedlings of tanglehead, black grama, and sideoats grama were established in exclosures than on grazed areas, but the grazed areas produced more seedings of wolftail, Arizona cottontop, Rothrock grama, curlymesquite, sprucetop grama, and slender grama. The number of seedlings per year on meter-square plots ranged from 0.5 for Arizona cottontop on ungrazed areas to 29 for Rothrock grama on grazed plots.

Yearlong grazing shortens life of mid-grasses, lengthens life of grasses with dense basal foliage. Black grama, mesa threeawn, Arizona cottontop, and sprucetop grama are long-lived grasses, with some plants living 10 years or more. Rothrock grama, with maximum age of 5 years and average age of 1.3 years, is the shortest lived perennial on the Santa Rita. Except for Arizona cottontop, the species that lived longer on grazed plots were short grasses with mostly basal foliage. On the other hand, the plants that lived longer under protection were mainly mid-grasses. These differences in response to grazing help explain why the percentage of mid-grasses increases in response to moderate to light grazing, and decreases under heavy grazing.

Moderate stocking and alternate-year summer deferment improve rundown ranges. In 1954, the mesquite was killed on two pastures and was left undisturbed on two others. Since 1957, each pasture has been deferred during the summer growing season every other year and utilization of perennial grasses has averaged around 40 percent when measured in June. Grazing capacities have increased on both pairs of pastures. The estimated number of animal units required to graze 40 percent of the perennial grass crop increased by 169 percent between 1954 and 1961 on the mesquite-free pastures, an average of 2.5 head per section per year. Where the mesquite was alive, grazing capacity increased 62 percent, an average of 1.1 head per section per year during the same period.

Since such grasses as blue grama and buffalograss do not need to be used seasonally, division of pastures into small areas and rotation in the use of pastures does not seem as desirable in the High Plains area as in some other parts of the United States. Where considerable areas of the less palatable grasses are included in the pastures having blue grama and buffalograss, it is sometimes practical to fence these areas separately to insure more uniform use.

Blue grama and buffalograss should not ordinarily be grazed to a height of less than 2 inches and the taller grasses should not be grazed this close. Over a period of years conservative grazing of the grass will produce the highest yields of beef. As one rancher put it, "We found out a long time ago that we produced heavier calves and had a higher percentage calf crop when we grazed our pastures so that we had grass left over."

Merrill, Leo B. and Vernon A. Young. 1952. Range Management Studies on the Ranch Experiment Station. Texas Agric. Exp. Sta., Progress Report 1449, 4 pp., illus.

A study was initiated in 1949 on the Ranch Experiment Station between Sonora and Rocksprings, Texas, to determine the rate of improvement of pastures under various systems and intensities of grazing, as compared with ungrazed pastures.

Four 60-acre pastures were established as a rotation unit in which cattle, sheep and goats were grazed at the rate of 32 animal units per section (an animal unit being one steer, or six mutton goats or six unbred yearling ewes). All animals were placed in the pastures as yearlings and were removed and sold when 2-year-olds.

Pastures were designated as 15, 16, 17, and 18. Pasture 15 was deferred through March, April, May and June 1949, while pastures 16, 17 and 18 carried the livestock equally distributed among them. During July, August, September and October 1949, pasture 16 was deferred and pastures 15, 17 and 18 were grazed. During November and December 1949 and January and February 1950, pasture 17 was deferred and pastures 15, 16 and 18 were grazed. In March, April, May and June 1950, pasture 18 was deferred and pastures 15, 16 and 17 were grazed. Then the deferment cycle was repeated.

Two 28-acre pastures were set up as checks, one to exclude livestock and the other to exclude both livestock and deer. Before the livestock were turned in, a vegetation survey was made on randomized plots in each pasture. These pastures were found to be comparable in ground cover composition, with curly mesquite the dominant grass.

The per head gains the first year were considerably more on the rotation pastures than on the heavily-stocked (48 A.V.'s/section) pastures, and slightly less than on the moderately-stocked (32 A.V.'s/section) yearlong pastures. During the second year the greatest gains per acre were made on the moderately-stocked pastures grazed yearlong.

During the extremely dry period from September 1, 1950, through June 30, 1951, the lightly-stocked (16 A.V.'s/section) and rotation pastures maintained the best vegetational cover.

The rigor and productiveness of the desirable grasses in the two ungrazed pastures were comparable with those in the lightly-stocked pastures and with pasture 15 in the rotation series, which was deferred during March, April, May, and June 1949 and in July, August, September and October 1950.

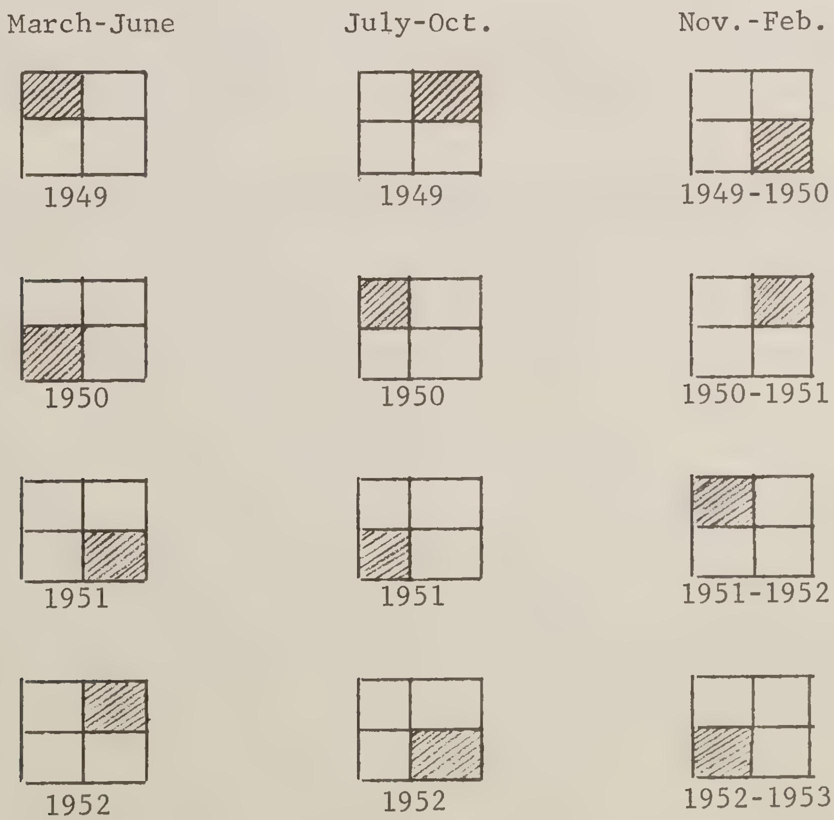
Merrill, Leo B. 1954. A variation of deferred rotation grazing for use under southwest range condition. Jour. of Range Mgt. 7(4):152-154. illus.

"The majority of rotation grazing studies have been conducted on two or three pasture systems and most of these systems concentrate livestock on one pasture while the remainder are resting. It would seem that as rainfall diminishes such a system becomes more and more hazardous since, during the period of concentrated grazing, a pasture might be damaged to the extent that it could not recover during the ensuing rest period."

A deferred rotation system was established at the Ranch Experiment Station on the Edwards Plateau of Texas in a comparison with continuous grazing at three rates of stocking from July 1, 1949, to June 30, 1953, using a combination of three classes of livestock--cattle, sheep and goats. Yearly rainfall for the three years, 1950-53, was 14.61 inches, 6.96 inches and 4.91 inches.

Three rates of stocking were employed, heavy at 48 animal units per section, moderate at 32 animal units per section and light at 16 animal units per section. Under the deferred rotation system, four 60-acre pastures were set up as a rotation unit in which a combination of cattle, sheep and goats was used as a moderate rate of stocking, or 32 animal units per section.

In the rotation system each pasture is grazed 12 months, then rested 4 months:



The rest period comes at a different season in each succeeding 16 months grazing cycle. During any given four years grazing each pasture is deferred once during each of the 4-month seasonal periods. Only one group of stock is moved every 4 months. The stocking rate on each of the three stocked pastures during any given 4-month period was 43 animal units per section, and when the deferred pasture was included it was 32 animal units (moderate) per section.

During the entire four-year period, sheep made the highest annual gain of 7.8 pounds per acre on the heavily stocked pastures grazed yearlong. The second highest weight gain of 6.8 pounds per acre was made on the moderately stocked rotation pastures, followed in order by the moderately and lightly stocked yearlong-grazed areas with gains of 6.1 and 3.1 pounds per acre. In succeeding years, the advantage in gain per acre held by the pastures heavily grazed yearlong steadily diminished, while the deferred rotation pastures made consistent gains.

Steers made nearly identical gains during the four-year period of 9.7, 9.8, and 9.9 pounds per acre from the moderately stocked rotation pasture and the yearlong moderately and heavily stocked pastures.

The initial survey indicated that all pastures had a similar cover of grass. The composition was: curly mesquite (77%), hairy triodia (13%), needlegrasses (6%), and desirable bunchgrasses (4%).

By the fall of 1952 the greatest vegetational composition improvement was made on the moderately stocked rotation pastures and on the lightly stocked pastures grazed yearlong.

A recent survey of grass survival following three years of severe drought showed curly mesquite suffered death losses under yearlong grazing of 91, 89 and 85 percent on heavy, moderate and light pastures. The moderately grazed rotation pastures showed a 78% loss in grass cover.

A steady trend toward improved range conditions as well as increased financial returns occurred on rotationally grazed pastures.

Moore, R. M., Nancy Barrie and E. H. Kipps. 1946. Grazing Management: Continuous and Rotational Grazing by Merino Sheep. Australia Council for Sci. and Ind. Res., Bulletin 201, pp. 5-69.

A pasture mixture of Phalaris tuberosa, subterranean clover (T. subterraneum), lucerne (M. sativa), and cocksfoot (Dactylis glomerata) established in 1939 at Canberra, A.C.T., was grazed by Merino wethers from June 1940 to October 1944, according to three systems of grazing:

a. Continuous grazing
b. 4-week rotation (1 week's grazing and 3 weeks' rest)
c. 8-week rotation (1 week's grazing and 7 weeks' rest)

The three grazing systems were compared on the basis of:

a. The yield and composition of the pasture.
b. The live weight, wool production, and health of the grazing sheep.

Wide fluctuations in pasture production and of carrying capacity were experienced as a result of variations in seasonal conditions. The carrying capacity of the pasture varied from 2 to 4 sheep per acre and averaged 2.84 sheep per acre over 4 years.

The yield of Phalaris tuberosa and subterranean clover, the major constituents of the pasture, was not affected by the method of grazing at any time, although a wide range of seasonal conditions was experienced.

Differences in pasture production under the three systems of grazing were relatively small and were due wholly to their effect on one constituent, lucerne. This summer-growing species, in a pasture mixture dominated by winter-spring growing species, was important only under a particular set of conditions.

Under continuous grazing lucerne had almost completely disappeared at the end of 4 years, and its contribution to the yield of the pasture was negligible. On the 4-week rotation the stand of lucerne was considerably reduced over the 4-year period, and its yield limited. On the 8-week rotation a productive stand of lucerne was maintained, and lucerne made an important contribution to the yield, particularly under the conditions of heavy summer rainfall in 1941.

The live weight of the sheep was equal on each of the three treatments except during the summer and autumn of 1942. Following the failure of normal spring growth in 1941, the sheep on all treatments lost weight between November 1941 and the end of February 1942. During this period the sheep on the 8-week rotation lost less weight than those on the 4-week rotation or continuously grazed plots. This difference was associated with the greater contribution of lucerne in the plots of the 8-week rotation during 1941 and the early part of 1942, and the failure of the subterranean clover.

There were no differences in the quality or quantity of wool grown by the three groups of sheep except in the 1941-42 season, which covered a period of 6-months drought. The sheep on the 8-week rotation produced fewer tender fleeces and slightly more wool than the sheep on the other two treatments during this period.

In view of the fact that Phalaris and subterranean clover form a stable pasture mixture under continuous grazing, and that lucerne, when included in such a mixture, is important only if these two species fail to make their normal spring growth, it is considered that the management of these species would be simplified if lucerne were to be grown as a separate crop, for hay under normal conditions and for grazing under adverse conditions.

The conclusion is drawn that, unless the stocking rate on a pasture can be adjusted so that the rate of consumption of the pasture is of the same order as its rate of growth, no increases in yield can be expected from rotational, as compared with continuous grazing of a botanically stable pasture mixture. Rotational grazing can be expected to give increases in yield only if conditions of growth are such that, as the same rate of stocking under continuous grazing, the degree of defoliation of the pasture is severe enough to cause the carbohydrate supply to become the factor limiting growth.

Morris, M. S. 1932. Can We Improve Our Range? Colorado Agric. Col., Ext. Serv. Bull. 313-A, 12 pages, illus.

The biggest crop in Colorado is grass. In spite of the enormous acreage of grass and its importance in our western agriculture, it is the poorest cared-for crop in the state. However, improvement of the range can be brought about. One of the most practical methods of range improvement is by deferred and rotation grazing.

Range land is the basis of the livestock industry and should be utilized in such a manner as to maintain a continuous supply of forage. Continuous grazing often results in complete destruction of the palatable and nutritious range plants, their place being taken by worthless or even poisonous weeds.

This method is based primarily upon the normal requirements of the most desirable plants on the range and the complete utilization of forage produced. The movement of stock is based upon the following conditions which are considered important in the life of the plant and the needs of the rancher: (1) Date plant growth begins in the spring, (2) date of seed maturity or plant maturity, (3) time required for seedlings to become established, and (4) utilization of forage produced.

Where long winter feeding of hay and grain is necessary as in our mountain areas or on range land which provides grazing for about 6 to 9 months, the method can be used.

The additional expense required in fencing was more than offset by the increase in forage. It was found that the acreage required for one head of stock could be reduced to 5 acres where it formerly took 7 acres.

The system favors the growth of the more valuable grasses and other forage plants and reduces the poorer-quality plants and poisonous weeds.

Where high-yielding grasses such as western wheat grass and needle grasses are present, the range produces green forage earlier and for a longer period.

Forage plants, on ranges where deferred and rotation grazing are practiced, are taller and produce more seed and show increased yields.

Ranges grazed under this system show as much as 53 percent increase in abundance of wheatgrass and a like increase in other valuable forage plants.

Deferred and rotation-grazed ranges will yield 36 percent more forage and have 22 percent fewer weeds than ranges that are continuously grazed.

The deferred and rotation system of grazing can be used in the mountain parks, the forest, the foothills and the plains and can be satisfactorily applied to meet different range conditions.

Morris, M. S. 1934. Deferred-and-Rotation System of Grazing. American Cattle Producer, 16(5): 3-5, illustrated.

A range area or native pasture should be divided into two or three parts of equal carrying capacity. If the pasture is divided into two parts, a simple application of the method will be used. Call one-half of the area "A" and the other "B." The procedure is then to allow area A to be grazed throughout the grazing season, while area B is protected from grazing from the time the plants appear green in the spring until they have matured seed (bunchgrasses), or have completed their growth for the year (sod-grasses) and are turning yellow. The protected or deferred area B is then opened to grazing, with area A to be grazed the remainder of the season.

This same procedure is repeated for another year, in order that seedlings which became established the first year may receive a year of protection, and the pasture itself may have two years of rest during the growing season.

The third year the procedure is reversed, or rotated. Area A, which was allowed to be grazed during the entire grazing season the first two years, is protected from grazing, or deferred, during the growing season for two years, while B is grazed continuously during the growing season for the same time. Rotation should be employed at the close of every two years until the pasture is returned to a satisfactory grazing condition; then rotation may be at one-year intervals.

The deferred-and-rotation system of grazing is of general value, as it can be applied to different types of ranching and to different kinds of native pasture. Hay meadows and tame pastures will fit into the system. The principal difference will be the off-pasture period. The deferred period should always provide protection during the growing season and permit dispersal of seed.

It has been found from measurements that western wheatgrass--one of the most valuable western forage grasses--is 53 percent more abundant in the deferred-and-rotation pasture than in the continuously grazed pasture. Other desirable plants, though not so abundant as western wheatgrass, showed an increase.

A general comparison of the yield of a deferred-and-rotation-grazed pasture and a continuously grazed pasture shows that the continuously grazed pasture yields 64 percent of the former in desirable plants and has 22 percent more weeds than the deferred-and-rotation-grazed pasture.

The effect of grazing on the size of forage plants is also of importance. Measurements of western wheatgrass on both continuously grazed and deferred-and-rotation-grazed pasture shows that in the latter the grass is 22 percent taller. Measurements on needlegrass--another valuable forage plant--showed an increase of 33 percent in growth on the deferred-and-rotation pasture.

Needlegrass is one of the important grasses in these pastures which produce seed year after year. It is highly desirable as a forage plant before seeds form and after seeds drop. It is the first grass to appear and is eagerly sought by livestock. Germination tests made on seed collected from grasses on continuously grazed pastures and on deferred-and-rotation-grazed pastures showed that the seed from the former was lighter and had much poorer germination.

Seed from grasses on a continuously grazed pasture weighed 28 percent less than that from a deferred-and-rotation-grazed pasture. Germination tests showed 32 percent germination for seed from a deferred-and-rotation pasture, but only 12 percent germination for seed gathered from the grasses in a continuously grazed pasture.

The value of the grasses of our ranges is determined by the earliness of starting growth in the spring, the height of growth, and their yields in forage. These things must be considered in comparing results under different systems of grazing.

Buffalograss, grama grass, and threeawned grass not only start to grow late in the season, but are short grasses, producing less forage for cattle. Western wheatgrass and needlegrass start early in the spring and grow to a considerable height, naturally producing more available forage for cattle.

The western wheatgrass type of pasture produced 920 pounds of forage per acre, 530 pounds of which, or 58 percent, was western wheatgrass. The rest consisted of less important plants, for convenience classed as weeds.

The needlegrass areas yielded 890 pounds of forage per acre, 71 percent of which was needlegrass. The grama grass type of pasture yielded on equal areas an average of 550 pounds per acre, only 230 pounds of which was grama grass. This low yield of grama grass, as compared with buffalograss, is due to its more scattered habit of growth. Buffalograss areas yielded to test 620 pounds in all, with 465 pounds being buffalograss.

Deferred-and-rotation grazing favors the highest type of vegetation on an area with the benefits of a desirable pasture. This system of grazing can be used in the mountain parks, in the forests, in the foothills, and on the plains, and can be satisfactorily applied to meet different range conditions.

Mott, G. O. (?). Grazing Pressure and the Measurement of Pasture Production. Purdue University, Agricultural Experiment Station, Journal Paper No. 1575, pp. 18-23, illus.

"The grazing trial is considered by many to be a complex type of experiment endowed with large experimental errors. It has been pointed out, however, that the errors associated with the various animal and pasture measurements in the grazing trial are no larger than would be expected from an animal-feeding trial or an analagous agronomic type of experiment.

"In the grazing trial it is very important to choose a stocking rate which is near optimum for the species or management system under study, since failure to do so may lead to serious errors.

"The output per animal is the measure of quality of forage in the grazing trial. It is a function of the nutritive value and the rate at which the forage is consumed by the animal. It is expressed as a specific amount of product per animal. Time is usually defined on a daily or seasonal basis.

"The average number of animals per unit area of land for a prescribed period of time or the number of animal days per unit area are measures which express the yield of the pasture. The carrying capacity -- if it can be assumed that the stocking rate is near optimum -- should be the investigator's best estimate of the production of the pasture in terms of animal numbers.

"The product per unit area in terms of milk, meat, or wool is the unit of measure of most interest in the grazing trial since it is a combination of the quality and quantity of pasture produced.

"It seems appropriate to attempt a clarification of the following terms:

<u>Stocking rate</u>. The number of animals per unit area of land. This term bears no relationship to the amount of forage.

<u>Grazing pressure</u>. The number of animals per unit of available forage.

<u>Carrying capacity</u>. The stocking rate at the optimum grazing pressure.

"The term, 'grazing capacity,' is sometimes used as a synonym for carrying capacity. The term, 'grazing intensity,' is used as a synonym for grazing pressure.

"In comparisons between plant species, species mixtures, fertility treatments, grazing-management systems, and trials of a similar nature in which animals are being used to measure the pasture output, it is imperative that the grazing pressure imposed on each of the treatments should be equal except in those trials in which the direct effects of grazing pressures are being tested."

"Stocking the pasture below the optimum rate usually results in a higher rate of (animal) production. This is probably due to greater opportunity for selective grazing, resulting in a ration having a higher nutritive value. Stocking at the light rates indicates that rate has very little influence upon product per animal over a wide range. Stocking the pasture at rates greater than optimum greatly influences product per animal. As selective grazing is reduced and as the feed supply diminishes, the product per animal falls rapidly.

"A fixed stocking rate across all treatments in a trial, a practice followed by many investigators, can hardly be expected to measure differences in carrying capacity if such differences result from the treatments. It is also seldom true that two pastures treated alike (replicates) yield the same quantity of grazable herbage. If the number of animals per unit area is to give an accurate appraisal of carrying capacity, then this unit of measure must not be fixed, but be subject to adjustment so that the number of animals per unit of forage is maintained at an equivalent level for all treatments. The use of a fixed number of animals appears to be a carry over from the dry-lot feeding trial where it is convenient to have the same number of animals in each lot. In the grazing trial, the investigator is usually concerned with measuring the carrying capacity of the pasture as well as the performance per animal. It then becomes clear that he should be much more concerned about stocking the pastures at the same grazing pressure rather than at the same stocking rate.

"The failure of various investigators to graze their pastures at an equivalent grazing pressure in a large measure accounts for the lack of more consistent results in studies of grazing management systems. A comparison of a controlled grazing system with uncontrolled grazing may affect the output per animal or the output of herbage per acre. If a fixed stocking rate is used in such studies, then only the output per animal is really measured and no measure is obtained of the number of animals which the pasture will support.

"Having more forage available on a pasture than can be consumed by the livestock is analogous to offering more feed to the animals than they can consume in a dry-lot feeding trial. No one would think of charging the unconsumed feed to the animals in the dry lot and yet this is precisely what is done in the grazing trial when the pastures are not grazed to their carrying capacity and the animal product is expressed on a unit-area basis."

Mott, G. O., R. E. Smith, W. M. McVey, and W. M. Beeson. 1952. Grazing Trials with Beef Cattle at Miller-Purdue Memorial Farm. Purdue University, Agric. Expt. Sta. Bull. 581, 16 pages, illus.

This report includes the results of grazing trials on permanent pastures, conducted at the Miller-Purdue Memorial Farm during the years 1948, 1949, 1950 and 1951.

Five treatments on permanent grass pastures were studied in three replications arranged in a randomized block design. A sixth treatment also was in three replications but the pastures lay outside the other five treatments in another experiment. All of the pastures are located in the same general area and are considered comparable for purposes of this report. The experimental errors were computed for only Treatments 1 through 5.

A description of the six treatments is as follows:

Treatment 1. This pasture has been untreated with respect to lime and fertilizer for at least 75 years. The grazing has been continuous during the growing season.

Treatment 2. This pasture received lime to adjust the pH of the surface soil to 6.5. Fertilizer has been applied at the rate of 300 pounds of 0-20-10 annually since 1947. A three-paddock rotation grazing system with a 10- to 14-day grazing period has been used.

Treatment 3. This pasture received lime to adjust the pH of the surface soil to 6.5. Fertilizer has been applied at the rate of 300 pounds of 0-20-10 annually. In addition, 120 pounds of nitrogen in the form of ammonium nitrate have been applied annually in two applications of 60 pounds each. The first application has been made in early spring and the second about July 1 each year. This pasture is managed in a three-paddock rotation grazing system with a 10- to 14-day grazing period.

Treatment 4. The lime and fertilizer treatments for this pasture are the same as Treatment 3. The grazing management differs in that a continuous grazing system is used in the spring until about July 1 and again in the fall beginning from September 1 to 15. There is no grazing on this pasture during the 8 to 10 weeks of the summer period.

Treatment 5. This pasture was renovated with a field cultivator and disk harrow in 1948 and 1949. A seeding of Ladino clover and birdsfoot trefoil was established and grazing was started in 1950. Lime and fertilizer were applied in a manner similar to Treatment 2, and a three-paddock rotation grazing system was also used.

Treatment 6. This pasture was established on a prepared seedbed several years prior to 1948. The seeding consisted of a mixture of birdsfoot trefoil and bluegrass and the seeding was well established for the present comparisons. Lime has been applied to raise the pH to 6.5 and annual applications of 300 pounds of 0-20-10 fertilizer have been made. This pasture has been managed in a three-paddock rotation grazing system with 10- to 14-day period.

Pasture Treatments

Years	Check No Treatment Continuous Grazing	Lime Fertilized 300 lbs. 0-20-10 annually Rotation* Grazing	Lime Fertilized 300 lbs. 0-20-10 and 360 lbs. Ammonium Nitrate annually Rotation* Grazing	Lime Fertilized 300 lbs. 0-20-10 and 360 lbs. Ammonium Nitrate annually Deferred Summer Grazing	Lime Fertilized 300 lbs. 0-20-10 Renovated and seeded with Ladino clover and Birdsfoot trefoil Rotation* Grazing	Lime Fertilized 300 lbs. 0-20-10 Seeded Pasture of Birdsfoot trefoil & Bluegrass Rotation* Grazing
TABLE 1. DAILY GAIN PER STEER AS OBSERVED FROM ALL STEERS ON THE PASTURES.						
1948	1.14	1.13	.81	1.62	--	1.03
1949	1.37	1.27	1.27	1.65	--	1.14
1950	1.34	1.19	1.18	2.20	1.27	1.20
1951	1.07	.98	1.00	1.71	1.14	1.11
Average	1.23	1.14	1.06	1.81	1.20	1.12
TABLE 2. NUMBER OF OBSERVED STEER DAYS PER ACRE.						
1948	131	196	294	181	--	324
1949	120	157	266	235	--	294
1950	122	202	302	241	234	296
1951	123	205	268	184	254	307
Average	124	190	282	210	244	305
TABLE 3. PRODUCTION OF TOTAL DIGESTIBLE NUTRIENTS PER ACRE. COMPUTED FROM REQUIREMENTS FOR MAINTENANCE AND GAIN OF STEERS.						
1948	1069	1634	2252	1924	--	2608
1949	1242	1561	2638	2556	--	2796
1950	1063	1725	2479	2448	2010	2542
1951	1131	1960	2434	1929	2468	2900
Average	1126	1720	2451	2214	2239	2711
TABLE 4. PRODUCTION OF BEEF PER ACRE IS OBSERVED FROM ALL STEERS ON THE PASTURE.						
1948	149	222	237	346	--	334
1949	165	200	339	387	--	336
1950	163	241	356	531	298	354
1951	132	201	269	314	290	341
Average	152	216	300	394	294	341

*Three-paddock rotation grazing system. Each paddock grazed for 10 to 14 days.

Paulsen, Harold A., Jr., and Fred N. Ares. 1962. Grazing Values and Management of Black Grama and Tobosa Grasslands and Associated Shrub Ranges of the Southwest. U.S. Department of Agriculture, Technical Bulletin No. 1270, 56 pages, illus.

Studies of management practices on black grama and tobosa grasslands and associated shrub ranges have been under way in southern New Mexico since 1912. The Jornada Experimental Range was established that year as a 193,394-acre tract 23 miles northeast of Las Cruces.

Climate of the basin is typical of arid regions; there is an abundance of sunshine, a wide range between day and night temperatures throughout the year, low relative humidity, and low, extremely variable precipitation.

The average annual precipitation measured by 21 rain gauges varied from a minimum of 6.92 inches near the center of the range to 10.76 inches close to the mountains. Rainfall for the whole area averaged 4.64 inches during the July-September growing season.

Ranches that have a combination of range types, such as this, will benefit by grazing the principal forage species at certain times of the year. Although black grama is palatable to cattle at any time, grazing may be detrimental during its active growth. Stolons, which are produced at this time, are often grazed or dislodged before they become rooted. This seriously restricts the spread of black grama.

On the other hand, tobosa and burrograss are most palatable and nutritious during the summer growing season. They become much less so after growth is completed and the plants cure. Tobosa can withstand moderate grazing during the growing season.

Because of the difference in palatability and response of the major forage species, most of the cattle on the Jornada were turned onto the tobosa and tarbush ranges in the summer after forage growth began. The animals usually remained there until fall, when they were moved to black grama range or mesquite sandhills and creosotebush types where black grama was present.

Benefits from this kind of management were illustrated on two adjacent and one comparable black grama ranges. One area was grazed principally from October to July, and the other was grazed yearlong at approximately the same intensity. After 20 years, plant composition on the range grazed October to July was 72 percent black grama, 20 percent other grasses and only 8 percent snakeweed. The other area's composition was 69 percent snakeweed, 9 percent black grama, and the remainder mostly other grasses.

Advantages of deferring grazing during the growing season on ranges having a high percentage of black grama are also illustrated by the average surface-acre requirements and the percentage of animal units grazed from November to July on the three grass pastures for the period 1928-51:

Pasture	Percent of Grazing during November to July	Surface-acre Requirement
9	88.2	45.0
10	71.7	56.0
5	57.5	84.3

As shown, the surface-acre requirement varied inversely with the percentage of animal units grazed during the Winter-Spring period.

Pickford, G. D., and Elbert H. Reid. 1942. Guides to Determine Range Condition and Proper Use of Mountain Meadows in Eastern Oregon. U.S.D.A., Forest Service, Pacific Northwest Forest and Range Experiment Station, Range Research Report No. 3, 19 pages, illus.

Proper management of mountain meadows is fully as important as proper degree of use of key species. Season-long use, too early use, undue stock concentration and unnecessary draining violate proper management of meadows.

If a summer cattle range that contains meadows is subjected to constant grazing during the summer, the natural preference of livestock will result in the lush meadow vegetation being kept closely grazed throughout the growing period. This type of management offers little opportunity for the establishment of new tufted hairgrass plants, which are produced only from seed. When this situation occurs, proper degree of use on meadows is impossible to obtain without ridiculously low stocking.

Provisions for reseeding are needed to perpetuate the stand. Cross fencing the range, or fencing the meadows from the timbered range, and grazing under a rotated-deferred system will help to obtain this condition and will aid in saving an important and strategic feed resource from destruction. Rotation and deferment of mountain meadows should be a "must" on eastern Oregon sheep summer ranges.

Too early use of mountain meadows is wasteful. Sheep trample more forage than they eat on wet soils. Cattle punch up the soil and break the sod under the same conditions. Most effective use of meadow vegetation is made after the soil has become firm enough to withstand livestock trampling. Rotated and deferred grazing is helpful insurance that the use of meadows occurs during the proper season.

Rader, Lynn. 1961. Grazing Management Pays on Perennial Grass Range During Drought. U.S.D.A., F.S., Pacific Southwest Forest and Range Experiment Station, Res. Note #179.

Livestock producers in northern California experienced the effects of a second successive drought year in 1960. At the Harvey Valley demonstration grazing allotment on the Lassen National Forest where the longtime annual average is 18.0 inches, precipitation in 1960 was only 12.5 inches. Only 2.00 inches of this fell during the growing season, May through September. This relatively low rainfall followed severe drought in 1959 when only 9.6 inches of precipitation were recorded.

A shortened grazing season and reduced livestock weight gains were particularly critical on rangelands which were in poor condition at the beginning of the drought period. But on the Harvey Valley allotment, rest-rotation grazing permitted nearly normal returns from the range.

Each of 5 range units in the allotment was deferred from grazing two full seasons and two half seasons over a 5-year period. This allowed a 120-day grazing season in 1960. Forage production was below normal: meadows and open grasslands produced an average of 1600 pounds of vegetation per acre. They produce about 3000 pounds in average rainfall years. Because of the low production, all five units had to be grazed to provide feed for the permitted 515 head of beef cattle. Utilization on the two units scheduled for rest during 1960, however, was fairly light. Estimated utilization in these areas, based on volume of forage removed, was only 30 percent. For the allotment as a whole, utilization was about 45 percent.

On several adjacent allotments, where the method of grazing is season-long, cattlemen voluntarily removed their livestock two to three weeks before the end of the permitted grazing season because of a lack of forage. Utilization checks on these allotments indicated that 70 to 75 percent of the available forage was utilized.

As in most years, the rate of gain was higher during the first half of the grazing season, from about May 20 to July 20. Calves gained 1.65 pounds per head per day for this period and 0.60 pounds during the latter half of the season. Based on calf gains of 0.60 pounds per head per day during the latter part of the grazing season, an additional three weeks of grazing at Harvey Valley produced about 12.5 pounds of extra beef per calf grazed. Valued at $0.20 per pound, this was worth an extra $2.50 per head for some 235 calves sold off the allotment.

Ratliff, Raymond D., and Lynn Rader. 1962. Drought Hurts Less with Rest-Rotation Management. U.S.D.A., Forest Service, Pacific Southwest Forest & Range Exp. Sta., Res. Note #196, 4 pages, illus.

Five range units are used in the management of the Harvey Valley demonstration grazing allotment on the Lassen National Forest in California. Each unit is rested two full seasons and two half seasons during a 5-year rotation. After a full season's use, any one unit is rested a full season to allow the plants to regain vigor. The next year the unit is rested until mid-season to permit seed to ripen, then it is grazed for full livestock production. During the fourth year the unit is again rested season-long, this time to permit seedling establishment. In the fifth year of the rotation, the unit is grazed moderately the first half of the season and rested the second half. This permits regrowth and restoration of vigor. This grazing system has been in operation on the allotment since 1954.

The year 1961 was the third consecutive year of drought. The long term average annual precipitation is 18.0 inches. From July 1, 1960, to June 30, 1961, the precipitation was 10.7 inches. Summer rainfall also was scanty with 0.5 inch of rain in June, 0.7 inch in July, nearly an inch in August, and less than a tenth of an inch in September. This dry season followed droughts in 1959 and 1960 when 9.6 and 12.5 inches were recorded.

One hundred head of yearling heifers were selected for weighing in 1961. Their mean weight was 518 pounds when they went onto the allotment June 5. At mid-season, July 26, the mean weight was 616 pounds, an average gain of 1.9 pounds per head per day for 51 days. Average weight of the yearling heifers on September 29 was 669 pounds. Mean gain per head per day for the last 65 days of the season was 0.8 pounds, and the average daily gain for the 116-day period was 1.3 pounds per head per day. Good gains were obtained in the third year of drought, without using range supplements.

During the 1959 drought, yearling heifers that grazed season-long in one unit gained as much or more than those moved to new, ungrazed range at mid-season. This comparison was not made in 1960. In 1961, when performance of heifers was again compared, those that grazed season-long in one unit did as well as those moved at mid-season.

A sample of open heifers moved at mid-season made greater gains for the season than a like sample of those grazed season-long in one unit. The difference was the result of greater gains made the first half of the season and not to any difference in gain the second half.

In 1960 unit 1 was grazed only the first half of the season and unit 5 was practically ungrazed. These units successfully bore the brunt of the grazing in 1961. It was felt that they were able to do so as a result of the grazing system. That, with rest-rotation management, the three years of drought hurt the range and rancher less than on similar ranges where season-long management was practiced.

Ratliff, Raymond D. 1962. Preferential Grazing Continues under Rest-Rotation Management. U.S.D.A. Forest Service. Pacific Southwest Forest and Range Experiment Station, Research Note #206, 6 pp., illus.

Rest-rotation management is being tested on the Harvey Valley range allotment on the Lassen National Forest in Northeastern California. A combination of fencing, salting, water development, and range ruling was used to obtain more even distribution of grazing pressure. The allotment is divided into fine fenced units of about equal grazing capacity. Each grazing season, one unit is stocked fully for the entire season, a second unit is stocked moderately for the first half of the season, and a third unit is stocked fully for the second half of the season. The other two units are rested season-long.

Utilization was estimated on the three units grazed in 1961 by the percentage-of-plants-ungrazed method. Only plants entirely available to grazing animals were included. Results showed that even with the attention given to distribution, preferential grazing continued.

Rest-rotation management provides two complete seasons and two half seasons rest from grazing for each of the fine grazing units over a 5-year period. While certain areas in each unit are preferred over others by cattle and are heavily grazed, the rest permits plants in all areas to regain vigor and produce seed. Rest also gives seedlings a chance to become established.

Reed, M. J. and R. A. Peterson. 1961. Vegetation, Soil, and Cattle Responses to Grazing on Northern Great Plains Range. USDA Forest Service Tech. Bull. No. 1252. 79 p.

During the period 1932-46, vegetation and soil responses to different intensities of grazing on mixed-prairie cattle range were determined at the U.S. Range Livestock Experiment Station near Miles City, Montana. Included were measurements of cattle responses associated with grazing intensity and estimates of proper stocking and herbage utilization.

Two sets of six native ranges were used; one set was grazed during late spring-summer-early fall (summer ranges) and one during the remaining seasons (winter ranges). Four were stocked heaviest, 23.1 acres per breeding cow, year-long; four intermediately, 30.5 acres; and four lightest, 38.8 acres.

Principal range subtypes were representative of those making up large expanses of the northern Plains. Most common forage plants were western wheatgrass, blue grama, needleandthread, green needlegrass, buffalograss, and threadleaf sedge which made up about 65 percent of the vegetation. The remainder was principally Plains prickly pear and big, silver, and fringed sagebrush.

A primary influence on vegetation was exerted by extreme drought during the period 1934-36, and near normal and much above normal weather during the following years. Basal cover and composition of vegetation, height growth of grasses, and production of palatable herbage were affected. Basal area of principal grasses charted in June and of all herbaceous vegetation combined, were closely associated with precipitation of the preceding growing season. In contrast, mature height of grasses and production of palatable herbage were normally closely associated with current growing season precipitation.

As indexed by herbage production and further evidenced by changes in other vegetation and surface soil characteristics, an early stage of range deterioration resulted under the heaviest level of summer grazing. This condition was characterized by the following changes:

Reduced height growth of vegetative, nonseedstalk-producing shoots of forage grasses was the most consistent vegetation change. It was accompanied by reduced weight per shoot. This was true for both the principal mid- and short grasses throughout growth and at maturity, and for all major sites. It was apparently one of the earliest responses and occurred regardless of how basal area and other vegetation characteristics were affected.

Basal area of all perennial grasses combined and of all herbaceous vegetation was generally increased. The increase was accounted for principally by buffalograss, and to a lesser extent by blue grama, perennial grasses of low or no grazing value, and annuals. Green needlegrass was materially reduced, and western wheatgrass where buffalograss had become abundant. In no instant was there a material invasion of low-value perennial grasses, perennial forbs, or annuals. Abundance

of Plains prickly pear and silver and fringed sagebrush was slightly favored. Density of big sagebrush was somewhat reduced.

These changes lowered production of palatable herbage and, in most cases, yield of all herbaceous vegetation. Increases of short grasses and secondary plants usually did not compensate for losses in production of important midgrasses. By decreases in height growth and a shift toward short grasses, a greater proportion of the weight of palatable herbage also became concentrated near the ground where it was less readily available to cattle.

Surface soil characteristics were affected through a reduction in litter cover, volume of roots, and organic matter. Volume weights were increased and noncapillary pore space reduced. These changes lengthened the time required for absorption of applied water and decreased the depth to which rainfall penetrated.

Growth of young cows was suppressed under heaviest yearlong grazing. Net summer gains were reduced throughout the study and weights generally lowered throughout the year. Growth of spring calves was retarded. Weaning weights were decreased about 50 pounds during the drought period and 30 pounds during the more normal years. On the other hand, hay requirements were increased one-quarter ton per cow per year and length of feeding period extended.

As compared with the heaviest grazing rate, the intermediate and lightest rates maintained cattle performance and range condition at a higher and nearly equal level. This equality was partly caused by a smaller difference in grazing than suggested by the surface-acre stocking rates, because palatable herbage production per acre of the intermediately stocked ranges was higher. Under intermediate grazing, however, height growth of grasses was slightly decreased. This suggests that more serious changes might have developed with continued grazing.

As a starting check on management, a minimum of 31 acres of range in good condition should be provided in this vicinity per breeding cow per year under the system of separate summer and winter range tested. A guide to herbage removal is suggested. However, under any intensity of herbage utilization or grazing system, the surest way to satisfactory long-term range maintenance and accompanying high sustained cattle production is a continuing check on range condition.

Recommmended allowable herbage use on range in good condition:

- Western wheatgrass - 55% of the individual shoots grazed on the upland, and 75% on the bottoms.
- Blue grama - 40-45% of the clumps on which one-half or more of the area has been grazed for the uplands, and 65% of the clumps similarly grazed on the bottoms.
- Needleandthread - 55-60% of the clumps grazed as in the case of blue grama.
- Threadleaf sedge - 50% of the clumps grazed as in the case of blue grama.

Reynolds, Hudson G. 1959. Managing Grass-Shrub Cattle Ranges in the Southwest. USDA, Forest Service, Agric. Handbook 162, 40 pages, illus.

Santa Rita Experimental Range is an area of about 52,000 acres. It is on a gently sloping plain that drains northwest into Santa Cruz River. The general topography is interrupted by a few stony buttes and low foothills, and by numerous drainage channels.

Precipitation is almost entirely rain. About half of the annual rainfall comes during July, August, and September, and about 40 percent of it comes during the 6-month period October through March. April, May, and June are the driest months of the year. Typically, the rainfall pattern consists of a summer peak, a winter plateau, and a late spring drought. About once in 10 years rainfall is unusually high in the winter or spring.

At the highest elevations, perennial grasses make up three-fourths of the plant composition. Shrubs are sparse but some, such as falsemesquite and Wright eriogonum, are good browse. Important perennial grasses are the gramas--sprucetop, black, slender, sideoats, and hairy--Arizona cottontop, and threeawns. Miscellaneous grasses of lesser importance are Rothrock grama, plains lovegrass, green sprangletop, and curlymesquite.

Shrubs are dominant on the range at the lower elevations, and annuals and scattered clumps of perennial grass grow between them. The main woody species are burroweed, velvet mesquite, and cholla. Also present are such shrubs as creosotebush, desert zinnia, longleaf ephedra, fourwing saltbush, and shortleaf baccharis. Perennial grasses, mainly bush muhly, Rothrock grama, Arizona cottontop, and sand dropseed, are sparse. Fluffgrass is the most abundant species. Annual grasses outproduce perennial grasses during years of favorable rainfall.

Summer deferment benefits the desirable perennial grasses. The following tabulation shows how the proportions of species changed under two treatments between 1937 and 1948 on a unit of Santa Rita Experimental Range:

Treatment and Perennial Grass Species	Composition 1937 (percent)	1948 (percent)
Summer deferred:		
Desirable species:		
Arizona cottontop	0	6.1
Black grama	6.1	11.1
Bush muhly	0	1.0
Tanglehead	1.5	22.2
Santa Rita threeawn	29.3	27.3
Other	0	1.0
Total	36.9	68.7

Treatment and Perennial Grass Species	Composition 1937 (percent)	1948 (percent)
Less desirable species:		
Rothrock grama	46.2	19.2
Threeawns, misc.	16.9	12.1
Total	63.1	31.3
Total perennial grasses	100.0	100.0
Grazed yearlong:		
Desirable species:		
Arizona cottontop	3.1	15.5
Grama:		
Black	16.1	15.0
Sideoats	1.0	3.1
Sprucetop	3.5	1.0
Bush muhly	2.4	4.3
Tanglehead	.7	6.9
Santa Rita threeawn	34.1	24.9
Other	3.8	1.0
Total	64.7	71.7
Less desirable species:		
Grama:		
Rothrock	12.3	10.8
Slender	13.4	6.9
Threeawns, misc.	9.6	10.6
Total	35.3	28.3
Total perennial grasses	100.0	100.0

Under summer deferment, grazing was from November through March each year, when the perennial grasses were mostly dormant. Over the 11 years, this range showed greater improvement than the adjacent check range grazed yearlong. Desirable grasses increased from about one-third of the perennial grasses to two-thirds whereas the less desirable grasses decreased from about two-thirds to one-third of the composition. Arizona cottontop, black grama, tanglehead, and bush muhly, all increased. Rothrock grama, a less desirable grass, decreased from about one-half of the total stand to about one-fifth.

The check range grazed yearlong was in better condition in 1937. It was also grazed conservatively during the study period. Under this type of use, the relative abundance of the desirable grasses increased slightly. They made up 65 percent of the perennial grasses in 1937 compared with 72 percent in 1948. The relative abundance of Arizona cottontop, bush

muhly, sideoats grama, and tanglehead, all desirable grasses, increased materially. However, black grama, sprucetop grama, and Santa Rita three-awn decreased. Rothrock grama and slender grama, less desirable species, also decreased in relative abundance but not to the same extent as on the range receiving summer deferment.

Black grama is very palatable and it is perhaps the most important single species of grass-shrub ranges. Because it spreads by above-ground runners or stolons during the growing season, the species is severely restricted if these runners are grazed. Accordingly, where black grama makes up a high proportion of the perennial grass composition, summer deferment is particularly beneficial.

On a well-managed range near Sonoita, Ariz., grazing is deferred during the summer growing season on one-fifth of the range each year, and the area deferred is rotated so that each area is rested once in 5 years. The excellent condition of this range testifies to the advantages of this recommended method of deferred grazing in combination with conservative stocking.

Ridings, R. N. 1960. Range Improvement Through Grazing Management on the Bead Allotment of the Gunnison National Forest, Colorado. Abstracts of papers presented at the 13th Annual Meeting, ASRM, pp. 53-55.

The Allotment Today

The Bead Cattle Allotment on the Cebolla Ranger District of the Gunnison National Forest has a net acreage of 6,269 acres. Of this acreage, 3,285 acres are classed as unusable, 2,984 acres are classified as usable acres. At one time these approximately 3,000 acres supported 2,700 head of sheep, 20 horses, and 178 cattle for a grazing period starting in early May and lasting until Christmas. Rapid deterioration of the range resulted from this severe overstocking and it has taken some 40 years to restore the vegetation to a good overall condition. A history of use and the associated range management practices, which have changed the allotment from a poor overall condition to a good overall condition, were recorded. Most of this information has been obtained from the sons of the original settler--with ranches in this area.

History of Use

In the late 1800's the Ute Indians were quartered on the Los Pinos Drainage approximately eight to ten miles south of this allotment. They gathered there in the fall to get their beef ration from the Government and to hunt deer. Records indicate that elk were not in this area at that time. The Indians burned the timber to drive a herd of deer past the hunters and as a result numerous stands of Aspen now cover this allotment. In 1894 the first settler in this particular area was a Mr. E. A. Mitchell; and he brought into the country 135 long-horn cows and bulls, and 20 head of horses. He arrived in the middle of the summer and turned his stock out onto the open range, gathering them as the winter storms drove them into the valley. The primary difficulty, at this time, was gathering his cattle out of the heavy timber.

At the turn of the century, a sheepman named Lawrence came into the area with 1500 head of sheep and he grazed wherever he could find food and water for his sheep. At this time there was no severe conflict between the cowman and the sheepman. The cow use of the area was governed by the abundance of larkspur and its location. After the establishment of the Gunnison National Forest in 1905, 90 head of cattle were permitted from April 1 to November 13. The total animal months use, including sheep (converted from sheep months to animal unit months) equaled 1395 animal unit months per year. During this period of years, 15 to 25 head of horses were turned loose on the range and grazed almost yearlong. The ownership of the colts, loss of salt, "grubbed-out" bottom land, and foul water holes were the basic problems between the stockmen.

During the periods 1910 to 1920 Mr. Mitchell, the original pioneer in the area, purchased cattle until the number averaged 178 head per season

and ran on the National Forest from September 1 until the first of the year. He still had for "companions" 2,700 head of sheep and approximately 20 head of horses. During this ten-year period the stocking rate on this allotment was almost one animal unit per usable acre. The yearly average stocking rate during this period was 2,642 animal months. Feed was hard to find for all of these animals and boundaries of the National Forest, the unappropriated public domain, and homestead lands were often violated.

Approximately the same rate of stocking prevailed for these years as in the preceding ten years, but with a decrease in length of season. An attempt was made during this period of years to establish smaller grazing units on the National Forest. Prior to this time the entire Sawtooth Mountain had been considered one unit. The first division was halfing the mountain North and South into two units. An attempt was made to continue sheep and cattle use to specific drainages rather than wherever they could drive them to find feed. The annual average total animal unit months use was 1,648 per season during this period of years.

From 1930 to 1940 the use on the area was fairly stable, but for a lesser number of sheep and a shorter season. The use dropped slightly to an average annual use of 1,435 animal unit months. In 1938 the present permittee noticed the first elk track on this allotment.

The use on the area was reduced further by reducing sizes of bands of sheep and numbers of horses and cattle. During these years the average annual month's use was 1,333 animal unit months.

Later two bands of sheep were taken from the area. As a result the grazing pattern from 1945 to 1956 was a thousand head of sheep in the spring and in the fall, and 185 head of cattle for the summer season. From 1956 to date dual use has been eliminated on this allotment. The range analysis of capacity indicates 492 animal unit months for the allotment. The use to date has been about 480 animal unit months.

Changes in Management - Regulatory

The early days of grazing on this area involved very little management. Riding was done to protect ownership or enhance ownership, or to herd sheep and horses or to lose sheep and horses, depending on who did the riding. With the establishment of the National Forest in 1905, limited grazing plans were effected by the Ranger in charge with the permittees using the area. From the 1920's through the 1930's allotments were established, use of National Forest was controlled, and improvement work started. Salting by the wagon load was starting to be a thing of the past. During the period 1940 to 1950 great strides were taken in re-evaluating the productivity, use, climatic, and edaphic factors, and vegetation conditions of the range. As a result of this work, more intensive range management was practiced, and dual use eliminated.

Changes in Management - Permittee

From the time the present permittee was a small boy, 45 or 50 years ago, he has been riding the range almost daily, except for the early part of September when, by necessity, he must leave the cattle to put up his hay crop. Very few ranchers spend more time tending their cattle, herding them away from overused areas, scattering them, and eliminating bottom land concentrations than does this permittee. In summer he scatters his cattle throughout the Aspen grassland type which is indigenous to this area. He also herds them away from the old sheep bedgrounds and attempts, by salting and riding, to utilize the upper areas of the allotment. We have in the past four years constructed five stock water ponds on the allotment to obtain better distribution of the cattle and better utilization of the area. The boundary of the allotment has been fenced by the Forest Service and the permittees affected. We have initiated this year a program of rotational use on the allotment without fencing but with considerable riding. Utilization checks indicate that we are probably understocked on the allotment today and we have offered the permittee a chance to increase his cattle numbers. But he is reluctant to do so until he has rehabilitated this area, severely abused by past grazing.

Rodgers, Richard S. 1966. Rotational-Deferred Grazing as Applied to Nebraska Sandhill Ranges. Abstracts of papers presented at the 19th Annual Meeting, ASRM, pp. 50-51.

In 1931 an initial purchase of 40,000 acres of Nebraska sandhills was made by the Bureau of Biological Survey for what was to become the Crescent Lake National Wildlife Refuge.

Aside from several exceptionally large lakes, which were among the main reasons that this specific area was selected as a waterfowl refuge, this section of the sandhills is typical of this part of Nebraska. The area is one of rolling, grass covered, sandhills with an interspersion of numerous small, sump lakes.

The initial refuge purchase was of a single large private holding. As a provision of sale, a ten-year grazing lease was retained by the seller. Few restrictions were imposed and as a result of this and the dry years of the thirties, all ranges were in poor condition when complete administrative control was obtained in 1941.

The first fully administered grazing was initiated shortly after the sellers lease expired. Stocking rates were first based largely on local recommendations.

In 1951 all grazing lands within the refuge, which by this time had grown to a total of 46,534 acres, were surveyed by Soil Conservation Technicians using site and condition class techniques. Following an indicated reduction in use, the ranges were then stocked on the basis of the survey recommendations.

In 1959 some of the problem summer ranges were placed under two or three part rotational-deferred systems of use.

In 1964 another complete survey was accomplished by Soil Conservation Service personnel.

Results of the last survey indicated that on the large summer ranges, which represented 76% of the grazed area, the suggested stocking rates had increased 25% from 1951 to 1964 and that 70% of the ranges were in "b" or better condition. Most of the improvement had occurred during the period 1959-1964.

Much of the increase was the direct result of the rotation-deferred type grazing. This paper details this type of usage and shows its application to sandhill and other ranges.

Rogler, George A. 1951. A twenty-five year comparison of continuous and rotation grazing in the Northern Plains. Jour. Range Mgt. 4(1):35-41. illus.

A grazing experiment was established at the Northern Great Plains Field Station in 1916 to determine the carrying capacity of native range. Pastures of various sizes were grazed with cattle continuously during a 150-day summer season from May 16 to October 13 at intensities that would result in degrees of use from overgrazing to undergrazing. In 1918 additional pasture was established to study a system of deferred and rotation grazing. This deferred and rotation pasture was grazed every year during the period 1918-45. The results obtained on this pasture are directly comparable with those from the continuously grazed pastures.

Temperatures reach extremes in both winter and summer, rainfall is limited and high winds are not infrequent. Normally about half of the annual rainfall comes in May, June, and July and the seasonal precipitation from April 1 to September 30 is about three-fourths of the annual. The average annual precipitation for the study period was 15.30 inches; the average seasonal precipitation 11.83 inches.

The dominant plant species are blue grama (Bouteloua gracilis), western wheatgrass (Agropyron smithii), threadleaf sedge (Carex filifolia), and needleandthread (Stipa comata).

A 70-acre pasture was divided into three divisions and grazed as shown:

Year	Period Grazed	Division 1	Division 2	Division 3
First	Spring	X		
	Summer		X	
	Fall			X
Second	Spring		X	
	Summer	X		
	Fall			X
Third	Spring		X	
	Summer			X
	Fall	X		
Fourth	Spring			X
	Summer		X	
	Fall	X		
Fifth	Spring			X
	Summer	X		
	Fall		X	
Sixth	Spring	X		
	Summer			X
	Fall		X	

Grazing on each division was deferred until fall during two successive seasons. This allowed production of seed on the fall-grazed division one year, and protection of the seedlings, if any, until fall of the next. Each division was grazed approximately one-third of the season each year.

Two-year-old steers were used during the period 1918 to 1934, and yearlings from 1938 to 1945.

There were two continuously grazed pastures: one 70 acres grazed moderately and the other 50 acres grazed heavily. The 70-acre pasture was grazed with one head to 7 acres for the 1918-40 period and with one head to 5.38 acres for the 1941-45 period. The 50-acre pasture was grazed at an intensity of one head to 5 acres from 1918 through 1940, and with one head to 3.85 acres from 1941 through 1945.

It was evident by 1936 when the shift was made from two-year-olds to yearlings that an intensity of one head to 7 acres was approximately the correct grazing rate for a continuously grazed pasture carrying two-year-olds for the summer season. It provided enough forage to produce the maximum gain per head, and the vegetation was not adversely affected. An average of about 25 percent of the total foliage remained for a carry-over to the next season. At this rate of grazing, changes in the composition of the vegetation were influenced primarily by differences in precipitation.

It was evident by 1940 that yearlings consumed about two-thirds as much forage as two-year-olds. The intensity of grazing was therefore increased by one-third on all pastures in 1941. The 70-acre continuously grazed pasture still provided a maximum of feed with plenty of carry-over forage.

The vegetation in the 50-acre continuously grazed pasture was definitely overgrazed at an intensity of one two-year-old to 5 acres for the 1918-34 period. Six times, the steers had to be removed before the end of the grazing season. The steers made lower gains, the composition deteriorated, and density decreased by approximately one-third.

The rotation pasture was grazed at the average rate of one head to 5 acres during the 1918-34 period. The vegetation did not show the adverse effects evident in the pasture grazed continuously at the same rate. Under rotation grasses benefited by the rest periods when they were periodically allowed to develop a normal growth and mature before being grazed. There was no evidence that the pasture benefited from any natural reseeding that took place in the fall-grazed divisions. The density of the pasture was so high at all times that old plants produced more competition than small seedlings could withstand.

For the 1918-34 (17 year) period when two-year-olds were used, gains averaged 34.8 pounds per head more on the rotation pasture than on the continuously grazed pasture with the same grazing intensity. The steers on the moderate continuously grazed pasture during the same period gained 44.5 pounds per head more on the average than those on the rotation pasture.

Yearling steers for the 1938-45 period grazed continuously at both moderate and heavy rates gained more per head than those on rotation pasture. At the rate of 5 acres and 3.85 acres per head the continuously grazed yearlings gained 20 pounds more per head on the average than those on rotation pasture at the same intensity. At the rate of 7 acres and 5.38 acres per head the continuously grazed yearlings gained 28.8 pounds per head on the average than those on the rotation pasture.

Under the conditions of the experiment which are similar to those throughout the northern Plains, moderate continous grazing of native range is conducive to maximum gains per head. It cannot be expected that gains per head can be increased by changing to a rotation system when there is sufficient forage for continuous season-long grazing with at least 25 percent carry-over of vegetation.

There would seem to be some merit in a rotation system for improving range that has been damaged by overgrazing.

One of the apparent advantages of continuous grazing is that cattle have access to all the plants in the pasture when highest in feed value.

Rowland, J. W. 1937. Grazing Management. Union of South Africa, Dept. of Agric. and Forestry, Bull. #168, 26 pages.

By means of sub-division, veld can be rested at certain seasons of the year. This method of control is also used where trek farming is practiced. The animals graze in one region during spring and summer and trek to another region for their winter grazing. From the point of view of the veld and its efficient utilization, there is much to be said in favor of this system, especially in view of the fact that the sour velds provide good grazing in spring and summer, while the value of the grazing declines rapidly in autumn. There are many sweet velds, on the other hand, which suffer severely if grazed before midsummer, for reasons which have already been outlined. These sweet velds are capable of producing autumn and winter grazing of the highest value. Land settlement and stock diseases are putting an end to trek farming.

The principle of deferred grazing is a sound one; and in order to introduce it into ranching practice in South Africa, Professor Bosman has recently suggested:

"The principle of deferred grazing could be applied to summer grazing areas in its simplest form in a scheme of 3,3,1,1."

The proposed grazing plan for summer crops would then be as follows:

	Early Summer	Late Summer	Winter Camps	Late Winter or Reserve Grazing
1st Year				
Camp A	Graze	Rest	--	Graze
Camp B	Rest	Graze	--	--
2nd Year				
Camp A	Graze	Rest	--	Graze
Camp B	Rest	Graze	--	--
3rd Year				
Camp A	Rest	Graze	--	--
Camp B	Graze	Rest	--	Graze
4th Year				
Camp A	Rest	Graze	--	--
Camp B	Graze	Rest	--	Graze

This modified deferred-grazing scheme reduces the necessity of dividing the herd into many groups. Only two camps for each group of cattle are necessary; while the one is resting the other is being grazed. No great division of the farm into camps or of the herd into groups is necessary.

It is submitted that this scheme could be adopted with advantage by every cattle farmer. It fits in well with our variable climatic conditions. It allows for revegetation. It provides for a reserve grazing area which could be utilized after the winter camps have been grazed down, and this reserve which has resulted from spring grazing and summer resting is much more valuable from the nutritional standpoint than would have been the case if a camp had been rested for the whole growing period.

Even where typical winter sweet veld cannot be reserved for exclusive winter use, this system fits in well, in so far as it supplies more valuable grazing during winter where the veld has been grazed in early spring and then rested. It is submitted that in regard to percentage cover and botanical composition veld treated in this manner should be beneficially affected.

The use of herd boys on large areas of veld for controlling the movements of animals so that certain areas are rested and others are grazed, as the stock owner requires, is definitely of value. It is cheap; and if carried out carefully, should be successful. There are certain considerations, however, to be taken into account. The successful herding of animals in the bushveld is by no means easy, because of the bush and resultant bad visibility, and also the fact that it entails restricting the movement of animals, so that they graze one area and refrain from grazing another area which is more attractive owing to its having been rested. Nevertheless, herding may be of some value under range conditions for aiding veld management where there is insufficient fencing. A wire fence, if it can possibly be afforded, is the most satisfactory and reliable and in the long run cheapest herding agent.

Sampson, Arthur W. 1913. Range Improvement By Deferred and Rotation Grazing. USDA Bulletin #34, 16 pages, illus.

In order to know exactly how to maintain a satisfactory forage crop, and how to manage lands in need of improvement in the best and most economical way, a study was inaugurated by the Forest Service in 1907, in cooperation with the Bureau of Plant Industry, in which the life cycle of the leading range plants on sheep lands within the Wallowa Mountains of northeastern Oregon was carefully observed. Statements and conclusions are based upon results secured from three years of careful study and two seasons of practical application in range management.

As it affects grazing management, the life cycle of forage plants may best be discussed under the following heads: (1) The production of foliage in the early growing season; (2) the production of flower stalks and seed crop; (3) the scattering and planting of seed; and (4) the establishment of seedling plants.

The amount of foliage produced early in the growing season and the promptness with which growth begins in the spring are direct indications of the vigor of forage plants and show the possibilities of revegetation.

The vigor of the vegetation greatly influences, in fact, sometimes determines (1) the time of flower-stalk production; (2) the number of flower stalks sent up; (3) the time of seed maturity and the size of the seed crop; and (4) the fertility of the seed.

A good example of the relation of plant vigor to the production of fertile seed is found in the case of mountain bunchgrass (Festuca viridula), which furnishes a large part of the forage between elevations of 6,500 and 8,000 feet in the mountains of northeastern Oregon. In the case of uninjured plants the flower stalks invariably began to show about 15 days after growth had started, and from 6 to 15 were produced from average-sized tufts. In contrast to this, the weakest individuals developed no flower stalks, while those less seriously weakened produced none for a month or 6 weeks after growth had begun. Even then the number sent up was invariably small, three being the average, and with a height but little more than half that of the stalks produced early in the season by strong plants.

Careful observations made in the case of 300 experimental areas on the important forage types showed (1) that the palatable and dependable perennial plants were not reproducing at all; (2) that only one perennial herb, known as sickle sedge (Carex umbellata breviostris), an unpalatable and useless species, was reproducing; and (3) that unpalatable annual weeds which mature their seeds at about the same time that the stock reach the mountain grazing lands, were increasing at a rapid rate, especially on the most seriously depleted areas.

To sum up the result from continued season-long grazing: Where there is enough stock to use all the forage each year the requirements of plant growth are seriously interfered with, the forage crop becomes weakened and is materially decreased, little or no seed is produced, reproduction is therefore prevented, and there is a gradual decline in the carrying capacity of the range.

This shows conclusively that (1) yearlong protection from grazing restores the vigor of the impoverished vegetation and promotes the forage production of the plants in existence; (2) the annual species with strong seed habits reproduce satisfactorily, but the more desirable and nutritive plants, especially the large-seeded species, reproduce only to a limited extent; and (3) while yearlong protection is favorable to the growth of the vegetation, it does not accomplish the planting of the seed, which is essential if the range is to be revegetated.

Deferred grazing is based upon the growth requirements of the vegetation from the germination of the seed until new plants have been established. The essential principles of the system are: (1) An overgrazed portion of the range, sufficiently large to supply the forage from the time of seed maturity until the end of the grazing season, is protected from stock until the seed crop has matured; (2) upon maturity of the seed crop the forage is grazed closely during the first season, but not to the extent of injuring the seed plants; (3) the same area is protected in the same way during the second and, if necessary, subsequent seasons, or until the new plants have been securely established; (4) when the area has been thoroughly reseeded, it is grazed early in the season and a second area, of sufficient size to accommodate the stock from the time of the ripening of the seed to the end of the grazing season, is protected until the forage has matured; (5) this method of alternating late grazing from one area to another is continued not only during the period required for the restocking of the lands, but even after the areas have been fully revegetated.

One of the greatest advantages of the deferred system of grazing is that the forage may be fully utilized while the lands are being reseeded. Though the range is not available for grazing until after seed maturity, the herbage, while not succulent at that time, is eaten with relish. Stock are not in need of succulent food in the latter part of the season, since a small milk flow is then sufficient for the lambs.

Perhaps the main advantage of deferred grazing, however, is that it plants the seed, which is so essential to reproduction. On an area grazed after seed maturity there were found seedlings of all important forage plants; on an adjoining yearlong-protected area only such species as white foxtail (Sitanion velutinum), the seeds of which have stiff barbs, were reproducing.

In range management under a system of deferred grazing the first things to consider are (1) the time at which the seeds of the important forage plants mature and (2) the proportion of the grazing season remaining after seed maturity. These things must be known in order to determine what portion of the range may be set aside for autumn grazing. In the Wallowa

Mountains one-fifth of the grazing season remained after the seed had matured, and accordingly one-fifth of the carrying capacity of each summer grazing division or allotment could be reserved annually for reseeding.

Sampson, Arthur W. 1914. Natural Revegetation of Range Lands Based Upon Growth Requirements and Life History of the Vegetation. Journal of Agricultural Research, Department of Agriculture, III(2): 93-148, illus.

Ideal range management would mean the utilization of the forage crop in a way to maintain the lands at their highest state of productiveness and at the same time afford the greatest possible returns to the stock industry.

To maintain the maximum productivity, the annual herbage crop must be used in a manner which will not retard the growth or prevent the perpetuation of the most desirable forage species.

On the other hand, if the stock industry is to receive the greatest possible returns at all times, the annual forage crop should be used when it is most needed and when the herbage is palatable and nutritious.

It is obvious that the requirements of the vegetation and the requirements of the stock are to a great extent antagonistic. Hence, unrestricted grazing, without regard for the vegetation or the locality, eventually results in decreased productivity and often in denudation.

Studies were undertaken by the Forest Service in cooperation with the Bureau of Plant Industry during the spring of 1907 in the Wallowa Mountains of northeastern Oregon. The studies were continued throughout the seasons of 1907, 1908, 1909, and 1910 and were followed by a practical application of the principles evolved to range management on lands within the Wallowa National Forest.

In the valley surrounding the Wallowa Mountains that is in the transition zone, at an elevation of 3,600 feet, the annual precipitation is about 17 inches, the greater part coming in the spring, autumn, and winter.

The essential features of the almost double life cycle of forage plants are: (1) Inception of growth, (2) flower-stalk production, (3) development and maturity of seed, (4) viability of the seed crop, and (5) establishement of reproduction.

In the case of plots clipped monthly, the vegetative growth decreased in abundance each successive season. In the fourth year the undisturbed herbage was exceedingly weak, short and sparse. No flower stalks were produced until the vegetation had been given one full season of rest and then only a few late weak stalks were sent up. On the plots clipped after seed maturity, however, the flower stalks were produced fully as early, as uniformly, and as profusely as in the case of the plants which had remained unmolested during the 5-year period.

Where the herbage had been removed monthly for three successive seasons, no seed was developed in the fourth year when the plots remained undisturbed. On the other hand, on the plots clipped annually after seed maturity, the seed crop was fully as large and matured at the same date as on lands from which stock was excluded.

To insure reproduction of the forage plants, the seed must in some way get itself planted. Though nearly all seed will germinate on the surface of the ground where there is abundant moisture, the resulting seedling plants in a locality where the soil dried out early in the season are unable to extend their limited root systems deeply enough to reach the moist lower strat and consequently die from drought.

From the facts brought out by the life-history studies, it is plain that a rational method of grazing should (1) avoid weakening the vegetation through continuous grazing prior to seed maturity, (2) utilize, so far as practicable, the trampling of the animals in planting the seed, and (3) provide for protecting the reproduction against heavy grazing until it is firmly established.

At the present time, grazing on the National Forests is carried out under one of three more or less distinct systems: (1) Yearlong or season-long grazing year after year, (2) yearlong or season-long grazing combined with an occasional total restriction of stock during the entire year for the purpose of giving the forage plants a chance to reproduce, and (3) deferred grazing, which aims at a rotation in the time of using each portion of the range, each year allowing an area to reach seed maturity before it is cropped, but grazing it after that period, in order to avoid loss of forage through nonuse and to assist reproduction by trampling in the seed.

The term, "grazing system," implies a definite plan of utilizing the forage crop in accordance with certain basic principles: yearlong or season-long grazing, however, is characterized mainly by a lack of system, since it fails to provide for the removal of the herbage at any particular time in any locality.

It may be said that season-long grazing continued year after year seriously interferes with the growth of the vegetation, decreasing both the quantity and palatability of the forage crop. By the failure of the forage plants to produce seed, reproduction is prevented, resulting in a gradual decline in the carrying capacity of the lands. Even under conservative use the carrying capacity of the range does not improve rapidly through reproduction of the more desirable species.

The system of yearlong protection is not an efficient one, because the most valuable perennial species fail to reproduce by seed. While the carrying capacity of the land is increased, this increase is slow and does not compensate for the waste of the forage crop during the long period necessary for revegetation.

Although, under deferred grazing, forage seedlings were found wherever there were enough parent plants to produce the necessary seed, the proportion of the seedling stand which ultimately became established depended mainly upon the habitat and climatic conditions, as well as upon sufficient protection from grazing during the period of establishment.

Notwithstanding the fact that half the stand in existence in the autumn is likely to be eliminated by grazing, the planting of an additional seed crop will, as a rule, fully offset this loss.

It may be said that the system of deferred grazing has proved highly successful wherever an adequate seed crop was produced. Its advantages over yearlong grazing and yearlong protection are (1) the restoration and maintenance of the vegetation without the loss of the forage crop in any year, (2) the planting of the seed, and (3) the removal of the vegetation itself, thus minimizing the fire danger from an accumulation of inflammable material.

The amount of range needed for grazing under the deferred system depends upon (1) the time at which the seed of the important forage plant matures, and (2) the portion of the grazing season remaining after seed maturity. In the mountains of northeastern Oregon one-fifth of the grazing season remains after seed maturity. Accordingly, one-fifth of the carrying capacity, but not necessarily of the total acreage, of each grazing allotment may be reserved annually for purposes of revegetation.

Sampson, A. W., and L. H. Weyl. 1918. Range Preservation and its Relation to Erosion Control on Western Grazing Lands. USDA Bull. 675. 35 pp.

The aim of this bulletin is to show the relation between range preservation and erosion and its control on grazing lands in the West. It is true, perhaps, that topography, climate, and soil are the primary factors in determining erosion; but, on the lands under discussion, the combination of these factors with the vegetative cover is such that erosion is slight where the natural conditions have not been disturbed and may be made serious by any influence which upsets the balance established by nature. Grazing may become such a disturbing influence by changing or destroying the vegetative cover. Numerous instances are on record where serious erosion was unknown until the ground cover was largely destroyed. On the other hand, in localities where the destroyed vegetation has been reestablished, a few typical cases of which are pointed out in the body of the report, serious erosion has been stopped.

The data were obtained, for the most part, on the high summer range of the Manti National Forest in central Utah, where the conditions influencing erosion are similar to those prevailing on many of the mountain ranges in Utah, Wyoming, Idaho, Nevada, Arizona, and New Mexico, and to some extent in other western States.

Every drop of rain that falls on more or less exposed soil has the power of removing soil particles, and with them the soluble salts essential to plant growth. Where the vegetative cover on a watershed has been largely destroyed the washing off of the surface soil may remove infinitely more decomposed vegetable matter and soluble plant food in a single season--indeed during one violent storm--than would be deposited by the decay of the vegetation in years. More than this, the resulting erosion, with its rush of water and debris, frequently ruins the lands where the debris is deposited and puts out of commission roads, trails, power plants, and other improvements. In many localities loss of property from this source has been appalling.

The greatest damage from erosion on range lands occurs where the areas have been badly overgrazed and the ground cover destroyed or seriously impaired. Before the ranges had been overstocked and the ground cover impaired, erratic run-off and erosion were practically unknown. After the breaking up of the vegetative cover in the early nineties, however, many streams originally of steady year-long flow and teeming with trout became treacherous channels with intermittent flow through which the water from rainstorms was plunged, or rose and fell according to the size and frequency of the storms and carried so much sediment in the water that fish and similar life could not exist.

The damage is not confined merely to the decrease in the forage yield on the range lands eroded and to the silting over of adjoining agricultural land to which the torrential floods carried the debris.

The importance of preserving the upper few inches of soil on the high ranges, and with it the vegetative cover, in order to regulate the stream flow, to maintain indefinitely the forage crop for grazing, and incidentally to prevent destructive erosion, is not always fully appreciated by the stockman and farmer. This is more especially true in localities where there is not an ample supply of irrigation water.

In the belief that more water would find its way into the irrigation canals if the vegetative cover were appreciably thinned out, there has been a tendency in some localities toward destructive grazing. For instance, several sheep owners have expressed a desire to be permitted to graze Ephraim Canyon so closely as to pack the soil firmly and to decrease appreciably the present density of that vegetation. They believed that a large amount of the water that is returned to the air in the form of evaporation from the vegetation, as well as that held by the rich surface soil, would, by thinning out the ground cover, be made available for irrigation. While it is true that if a given canyon were grazed destructively more water would undoubtedly rush down the water channels, and as a result a greater acreage of farm land could possibly be irrigated in early spring, there would be less water for subsequent irrigation at a time when the crops were seriously in need of it. With the destruction of the vegetative cover not even the lands most advantageously situated would have the benefit of a continous stream flow for subsequent waterings during the season when even a light irrigation might result in the production of at least an average crop. In addition an enormous acreage of choice farm land would be destroyed by sedimentation, to say nothing of the high cost of upkeep of the irrigation ditches themselves.

Within the boundaries of the Manti National Forest of Utah there is a belt of approximately 47,000 acres of land along the east side of the divide which is badly depleted as a result of overgrazing and erosion, making necessary a regulation protecting the areas from grazing part of the year. Along the west side of the divide there is a similar belt of about the same acreage where erosion is also causing damage. These belts are practically timberless, and are of value chiefly as watersheds, from which stream flow for irrigation is supplied, and for the grazing resources which they afford. That these and similar eroded lands would originally support a cow or the equivalent in sheep on from one-third to one-fifth the acreage required at the present time is evidence of the enormous loss annually to the livestock industry alone. The soil and plant foods on these already relatively unproductive lands continue to be carried away by the run-off following each storm; and the destruction, where well advanced, is sure to continue until preventive measures are fully established.

Typical instances of the damage caused by erratic run-off and erosion are well worth citing. On July 28, 1912, a rainstorm occurred at the

head of Ephraim Canyon, on the Manti National Forest, within a belt of 2 miles and between elevations of 9,000 and 10,500 feet. There was no rain in the valley or on the mountain below, approximately, 8,000 feet. The storm of 0.41 of an inch of rain fell intermittently, but at no time with special violence, for a period of two hours. A flood of sufficient force developed to reach to the city of Ephraim, 10 miles below, covering the streets and some farm land, and filling the basements of buildings with mud and debris. Laden with silt, logs, vegetable matter, and, during the most violent period, with rocks containing as much as 30 cubic feet of material, the flood destroyed wagon roads, trails, and water ditches.

Another typical example of flood and erosion occurred on July 30, 1912, when a flow of torrential violence originated at the head of Becks Canyon. A rain, amounting to 0.55 of an inch, the greater part of which fell within an hour, started at 11 a.m.; and at 11:45 a.m. a flood was pouring out of a small side canyon which drains into Becks Canyon from an area of less than 1,500 acres, at an elevation of about 10,000 feet. This area is virtually treeless and is fan-shaped, the main drainage channel originating at the head of a steep canyon which drops into Becks Canyon at the rate of about 1,000 feet in less than a mile. The soil is of a clay-loam type, and, considering the area as a whole, is of fair depth, there being but little outcrop. The slopes are moderately gentle, and because of this fact the area had not been included in the adjacent one which was protected from grazing until late in the season. An examination after the flood showed that the soil had been very densely packed by grazing previous to the storm. The whole of this small watershed was well marked with gullies. The flood was not observed until it reached the mouth of the side canyon. Here it presented a front approximately 8 feet wide and 1½ feet high. The water was so infiltrated with sediment that it did not run but rolled over and over, picking up small rock and gravel. The flow increased to a front of from 10 to 25 feet wide and from 6 to 8 feet high. The velocity and force of the rolling mass down the steep slope were appalling. The main flow lasted approximately one hour, varying in volume as had the rain 30 minutes previous. Owing to the enormous deposits of debris, the course at the mouth of the channel changed three times. As the stream changed its course from one side to another, enormous quantities of material were deposited only to be carried away later. At one time approximately 5,000 cubic feet of the bank was torn out in a few minutes as the old bed filled up with material from above. All these tons of soil, vegetable matter, and other material were carried down by the rushing water in less than two hours after the rain began to fall.

As the forage production on range lands is decreased as a result of erosion, the water available for irrigation purposes decreases. The surface soil, containing as it does the decomposed vegetable matter, is the chief absorbing and retaining agent of water. A series of tests to determine the water-holding power of soils at different depths was carried out by obtaining samples of a noneroded soil of limestone origin in the spruce-fir type at 10,000 feet elevation, the results of which were as follows: Water-holding capacity, from surface to a depth of

6 inches, 56.4 percent; 6 to 12 inches, 46 percent; and 12 to 24 inches, 32.4 percent. The percentage of organic matter contained in the soil samples was 15.8, 11.3, and 6.8, respectively. Hence the amount of water these soils retained against the force of gravity is roughly in direct proportion to the amount of organic matter intermingled with the soil particles. In the absence of this rich sponge-like soil surface, the water is readily carried away by gravity, and the stream flow for irrigation purposes is extremely erratic and available only for a short time following rainstorms. Obviously, it is often impossible for the farmer to avail himself of this flood water for irrigation purposes for at least two reasons--the water may assume torrential magnitude and carry with it so much sediment as not to warrant its use for irrigation purposes, or owing to its unexpected occurrence the farmer may not be able to make use of it.

In the spring of 1912, two areas, designated as A and B, as similar as possible in topographic, soil, and climatic conditions and vegetation, were selected for the study. The areas are located in the Manti National Forest at the head of Ephraim Canyon, on the rim of the Wasatch divide where fan-shaped drainage basing are characteristic.

Practically all the torrential floods which are responsible for the most serious destruction of property originate near the heads of the watersheds, usually at high altitudes. On the Manti Forest the most vital part of the watershed is that lying between altitudes of about 9,000 to 10,500 feet, within what is known as the spruce-fir type.

It is on these elevated lands that the rainstorms are the heaviest and most violent, the slopes are steepest, and conditions in general most favorable to erosion.

The greater part of this upper mountain region consists of large fan-shaped basins which drain through narrow canyons into the valleys below. These canyons are relatively short and have a steep grade. Ephraim Canyon, for example, has an average grade of about 22 percent, or approximately 1,160 feet to the mile. So rapid is the drainage of water from these high basins that, in rushing through to the steep canyons, relatively little of the rain is absorbed by the soil; most of it plunges into the valleys below.

On the selected areas, A and B, seven rather distinct plant associations occur, viz: Yarrow-needlegrass-cinquefoil; yarrow-Douglas knotweed; adder's tongue-larkspur-sweet sage; currant-gooseberry-yarrow; bluegrass-wheatgrass-needlegrass (semi-scabland); giant larkspur-blue foxglove-Douglas knotweed; and yellowbush-sweet sage-peavine. The density of each of these associations is shown on the map. Most of the species are valuable as forage and as soil binders.

The soil is of limestone and sandstone origin, though chiefly the former, and varies in depth from a few inches to several feet. While there is some outcrop on both areas, the soil for the most part is fairly well decomposed. The principal drainage channels vary from 2 to 9 feet deep. In many places wherever a vegetative cover is lacking rills occur, though most of these are less than a foot in depth.

The accumulation of the winter snows of 1915-16 showed a water equivalent of 9.1 inches on area A and 9.2 inches on area B. This represents approximately 326,800 cubic feet of potential water on each of the 10-acre areas awaiting the spring thaw. What becomes of the water from the melting of this snow? The water registers show that 292,998 cubic feet ran off area A, while only 42,216.8 cubic feet ran off area B. This difference in run-off is due to the fact that the soil on area B contains more organic matter and has a better ground cover than area A. A small part of the snow water, of course, evaporates into the air, but the greater portion of that not accounted for in surface run-off is absorbed by the soil. Part of the water that percolates into the soil finds its way to the main drainage channels and serves as irrigation water in the valley below; the remainder becomes an important factor in the promotion of growth of range forage. The run-off occasioned by the melting of the snow accumulated in 1915-16 caused the removal of 172 cubic feet of soil from area A as against 82 cubic feet from area B.

As might be expected, there is less sediment per cubic foot of run-off from melting snow than from summer rainstorms. Further, the total amount of sediment brought down is less than that deposited by the single rainstorm of July 21, 1915, although the stream flow from the melting snow was approximately seven times greater.

An examination of the rainfall and the resulting run-off, or lack of it, disclosed several interesting facts. In the first place, out of the 26 rainstorms for the year 1915, distributed over the four months from June to September, inclusive, only one storm--that of July 21--produced run-off. At this time, according to the record of the four rain gauges, 0.70 and 0.71 of an inch of rain fell on area A and 1.48 and 1.38 on area B, within a period of 65 minutes. From area B the run-off was 335 cubic feet and it carried 94 cubic feet of air-dry sediment, as compared to 3,019 cubic feet of run-off on area A and 717 feet of air-dry sediment. It should be kept in mind that the run-off from area A was enormously greater than on area B in spite of the fact that area A received less than one-half as much rainfall as area B.

The other 25 rainstorms of the year 1915, with the possible exception of one or two in June, produced no run-off, because they were of a much gentler nature, so that the soil was able to absorb the moisture as it fell.

During the rainy season of 1916, conditions were somewhat different from those of 1915. There were several storms covering periods of from two to five days successively. Naturally, storms of such duration have a greater effect in causing run-off than short, mild storms. It was found that the rain for a time, depending upon the prior condition of the soil as to dryness and compactness, was absorbed and there was no surface run-off whatever; but after the soil became completely saturated and the rainfall still continued, run-off occurred and with it was carried a large amount of sediment.

In practically all regions wind is sufficiently strong to cause soil particles not firmly bound by vegetation, to be carried from one place to another and subsequently to be transported downward by water. On elevated lands enormous quantities of soil are often carried away, not uncommonly causing uniform removal of several inches of the surface soil. This is in part due to the sparseness of the vegetative cover, especially of tree growth, and its failure to break the wind. On the more elevated lands the vegetation is usually less dense than at lower altitudes, so that the wind has considerable more effect and its velocity is considerably greater.

Considering the two locations month by month for the period given, it is evident that the wind movement during the growing season, which is practically the only time when the soil is exposed and subject to wind erosion in the higher type, is approximately 100 percent greater in the heart of the spruce-fir type at 10,000 feet elevation than in the aspen type 1,500 feet below.

The maximum velocity of wind in the spruce-fir type exceeds by about 200 percent that in the aspen type at certain periods. These gales on the elevated plateaus, especially where the ground cover is sparse, have a marked effect on the movement of the soil and without doubt are an important factor in causing erosion when the surface soil is dry and exposed. It is especially important, therefore, that the vegetable cover on these elevated lands be maintained in a maximum state of density in order to bind the soil firmly.

While the foregoing data indicate that the extent of surface run-off and erosion are determined by the combined action of a number of factors, the vegetative cover is the most important single controllable factor under the conditions in question. Man has little control over climate and topography, and improvement in soil conditions most favorable to the control of erosion on the range lands under discussion must be accomplished chiefly through the improvement in the vegetative cover. Even this possibility of control is limited primarily to what can be accomplished by management of the lands so as to favor the development of the native vegetation to the greatest possible extent because western range conditions in general are not favorable to the planting of cultivated species. This importance of the native vegetative cover in maintaining conditions unfavorable to erosion may be considered both a drawback and an advantage, for, on the one hand, certain precautions must be taken in

harvesting the forage crop in order to preserve and maintain the vegetation; but on the other hand, there are relatively few lands which, under proper management, can not be revegetated enough so that serious erosion and destructive floods may be prevented.

In order to determine the difference, if any, in the potential crop production and water requirements of plants grown on eroded and noneroded soils, samples of identical origin and type were selected for comparative study. The soils in question were selected in the spruce-fir type on typical summer sheep range at approximately 10,000 feet elevation. After being carefully sifted and thus freed of the larger pebbles, etc., the soils were moistened moderately and tamped firmly in cans 14 inches wide and 17 inches high. Six large test pots were used, three of which contained eroded and three noneroded soil, and each was planted to five seedling plants as follows: One set, consisting of one pot of eroded and one of noneroded soil, to a pedigreed field pea known as Kaiser variety; one set to native bromegrass, locally called wild oats (*Bromus marginatus semivudus*); and the third set to a pedigreed wheat known as Kubanka No. 1440.

The pots were hermetically sealed and so arranged that all the water loss from the soil had to pass through the plants in the form of transpiration or evaporation. The pots were weighed at regular intervals and water was added to the soil so that the moisture content was kept practically constant. Throughout the experiment the average moisture content was about 30 percent, a supply ample to produce the most vigorous growth on both soil types.

In all the constituents considered except potash, the noneroded soil is much the richer. The greatest difference is found in the total nitrogen content, one of the most important of plant foods. This is due to the fact that a large proportion of the nitrogen compounds are more or less soluble in water and consequently had been largely washed out of the eroded soil.

The vegetative growth and water requirement of peas on the eroded and noneroded soil, shows a remarkable contrast in the vegetative growth and other activities. The number of leaves is as 1 to 2.7; the leaf length, 1 to 3.3; the total dry weight produced, 1 to 8.3; and the water used per plant, 1 to 4.6, all in favor of the noneroded soil. In the water requirement per unit of dry matter, on the other hand, the ratio is reversed, being as 1.8 to 1 on the eroded and noneroded soils, respectively. Hence there are a great many more leaves, greater stem and leaf length, and more dry matter produced on the noneroded than on the eroded soil, with a notably smaller amount of water.

The establishment on eroded soils of a dense vegetative cover made up of desirable forage and other deep-rooted, soil-binding species, similar to the original type is a most difficult task. In the first place, owing to the low moisture content due to exposure and lowered water-

holding power, seed germinate poorly. Moreover, about nine-tenths of the plants which do come up die early in the spring while still in the seedling stage. The remainder usually dry up before the end of the season.

On analyzing the data recorded as to the rate and character of the revegetation, it was found that by noting the seriousness to which the soil has been eroded, and hence its physical condition, including the relative amount of organic matter contained in it, it is possible to predict with much precision not only the rate at which the ground cover may be restored but the particular kind of plants that will occupy the soil for a temporary period prior to establishment of a permanent vegetation. As a general thing, many years must lapse before the more desirable forage species can reoccupy the site upon which they formerly predominated. The reestablishment of the deeper-rooted perennial species, if this type of vegetation is desired, and it usually is, can be accomplished on these eroded soils under range conditions only by certain rather inconspicuous plants first gaining a foothold on the land and gradually reinstating the vegetable matter and plant foods which are invariably lacking.

While it is evident that the extent of run-off and erosion are roughly proportionate to the effectiveness of the ground cover in binding the soil, other factors being equal, the question as to whether run-off and erosion are augmented or retarded by grazing is one upon which opinions vary widely. Some stockmen contend that if a soil is cut up more or less by the trampling of stock, or the surface pretty thoroughly pulverized, more water will be held and subsequently absorbed by the soil than if the surface is undisturbed. Others are of the opposite opinion, contending that the packing of the soil, which unavoidably results from grazing, especially if the soil is fairly moist when stock travel over it, prevents the rain from being absorbed in maximum amounts. In carrying out the details of the experiment on the selected areas, strikingly significant results as to the effects of grazing and nongrazing were obtained.

On July 21, 1915, when both areas had been protected from grazing since August, 1914, a heavy rainstorm occurred in which area B received approximately twice as much precipitation as area A; but only about one-twelfth as much run-off and one-ninth as much erosion was recorded from area B as from area A. On August 5, 1916, area B was grazed closely by sheep, area A being at that time ungrazed. Late in the day of August 5, a rainstorm occurred in which both of the selected areas received an average of 0.25 of an inch of rain. Practically the same amount of run-off was recorded from the two areas, and the erosion from area B was one-half that from area A.

It will be noted, then, that the ratios of precipitation, run-off, and erosion on area B as compared with area A were changed from 2/1, 1/12, 1/8, respectively, to 1/1, 1/1, 1/2, respectively, as a result of grazing

area B and not area A. Since grazing was the only factor changed as compared with all previous records, it appears safe to conclude that the change in the ratios of run-off and erosion showing a marked increase in erosion on area B was due to grazing. Instead of a large proportion of the rain being absorbed, the soil surface on area B was so hard-packed by the trampling of the stock that the run-off was appreciably increased. Much of the sediment deposited was carried directly from the gullies, a large amount of loose dirt having been worked into these depressions as the sheep traveled over them.

The maintenance of a maximum cover of vegetation and continuance of grazing are naturally antagonistic at best, and unless certain recognized principles of range and livestock management are put into practice there is danger of impairing the ground cover.

One phase of mismanagement which is often overlooked by the stockman and which is responsible for serious destruction of the vegetation, is that of permitting stock on the range too early in the spring, when the herbage is very young and succulent, and when the soil is well-nigh saturated with moisture. A week to 10 days after growth starts in the spring the forage has very little "substance" and is rather deficient in sugars and protein as compared with forage which has been growing twice as long. At no time in the season is it more essential that a plant be permitted to develop its leafage, which is the laboratory for the production of food, than early in the spring. A few days' delay in the time of grazing following the inception of growth will not only insure the production of a much larger forage crop for that particular season but in subsequent seasons as well, and the herbage will have much more strength and fattening qualities. Then, too, the bad effects of trampling over the loose, wet soil is largely avoided and the exposure of the roots and subsequent drying out of a large proportion of seedling forage plants is prevented.

In the case of virgin range lands there will be no difficulty in maintaining indefinitely the vegetative cover provided the lands are not grazed beyond their actual carrying capacity and too early in the spring. But where the range has already been overgrazed and the original ground cover considerably thinned out, but not all of the seed plants destroyed, merely keeping the number of stock down to the estimated carrying capacity and preventing too early spring grazing are not in themselves effective means of reestablishing the desired vegetative stand. In such instances deferred and rotation grazing must be applied.

One of the most common causes of range depletion, even where the carrying capacity of the lands as a whole has been carefully estimated, the season of grazing adjusted, and the deferred and rotation system of grazing adopted, is the excessive grazing of one area and the nongrazing or very light cropping of another as the result of poor distribution of stock, improper salting, and faulty handling of the stock, especially sheep.

On the more important fan-shaped basins at high elevations, where the original vegetative cover, including the seed plants, has for the most part disappeared, and where the fertility of the soil has been seriously depleted as a result of erosion, the best plan is to discontinue grazing entirely. The small amount of forage produced, consisting, as it usually does, of annual weeds and many poisonous species, by no means compensates for the further skimming off of the already deficient organic matter and tearing down into the gullies of the loose soil. In most instances stock will not have to be excluded longer than during the period required to reestablish the fertility of the soil and the incoming of the deep-rooted, permanent type of perennial vegetation, provided, of course, that light grazing and proper handling of the stock are at all times resorted to. On the other hand, where the soil fails to regain its former productivity within a reasonable length of time, as indicated by the character and density of the vegetative cover following the exclusion of stock, grazing should be permanently discontinued. To graze such lands after a few years of rest, even though they produced a little feed, would be to undo in a season all that nature has accomplished in building up the soil during the seasons that stock was excluded.

Sampson, Arthur W. and Harry E. Malmsten. 1926. Grazing Periods and Forage Production on the National Forests. USDA, Dept. Bull. 1405, 55 pages, illus.

Stockmen in the West have always had confidence in the adequacy of the native forage crop to provide pasturage for their livestock. Indeed, under normal climatic conditions this enormous natural resource has not failed the grazier, except where it has been called upon to meet unreasonable demands. The productivity of the range has declined sharply, however, wherever the requirements of plant growth have been disregarded for many years in succession. Where there has been too early or too frequent and too heavy grazing, undue trampling, or some other unsatisfactory feature of range use, the results have been uniformly bad. Many conspicuous examples show that abundant nutritious forage can not be expected in the absence of rational grazing and livestock management.

The proper time for grazing to begin on a range, or the time of "range readiness," may be defined as the date in any one year when the range first reaches the condition in which there is sufficient feed to keep livestock in thrifty condition and when the stock may be admitted without serious impairment of the growth and reproductive processes of the more important forage plants. To determine when this condition is reached is a problem of prime importance in economical range management.

The time when livestock should be removed from the spring range to the summer range is determined chiefly by (1) the stage of growth and the abundance of forage on the summer range, (2) the grazing capacity of the early range as compared with that of the summer range, (3) the palatability of the forage on the spring range and the thriftiness of the animals grazed, (4) the water supply on both ranges, and (5) the need for and value of the forage on the early range for fall grazing.

The closing of the grazing period on summer and fall ranges is governed largely by (1) proper utilization of the forage, (2) weather conditions and the trampling of wet soil, (3) the condition of the livestock, (4) the availability of late fall and winter forage elsewhere, and (5) the availability of water.

The "deferred and rotation grazing plan" has been adopted widely on national forest ranges in order to obtain the greatest possible use of the forage and at the same time keep the lands in a high state of productivity. The plan is based upon the growth requirements of range vegetation, coupled with methods of handling livestock to foster seed production, provide for the planting of the seed crop, and furnish forage for the stock during the revegetational period. Briefly, the plan is to reserve some portion of the range for cropping after the seed has ripened. The following year, in order to avoid the destruction of

the seedlings which originated from the seed of the first year's crop, and to provide for additional seed where needed, the same area is usually reserved a second time. If after two years of such deferred grazing the forage plants have become vigorous and an ample number of seedling plants have become established, a second area in need of seeding is selected and the tract upon which grazing was originally deferred is cropped before seed maturity. This plan of deferring the grazing on one depleted area and then on another is continued until the entire range has been revegetated. After that, grazing after seed maturity is alternated or rotated from one portion of the range to another in order to allow an occasional seed crop of the better forage plants to develop and replace the decadent vegetation. This continuous rotation in the grazing plan has the big advantage over yearlong rest or of a heavy reduction in the stock during the period required for revegetation that it interferes not at all with the production of beef or mutton.

Deferred grazing has been attempted without adjustment in the number of stock on overstocked ranges where improvement in the plant cover was badly needed. Because of the overstocking it was necessary to crop the forage on the unreserved parts three or more times before seed maturity. These attempts have shown clearly that the deferred grazing plan can be applied successfully only if the number of livestock corresponds with the actual grazing capacity of the range; otherwise the parts grazed before seed maturity will be so seriously overgrazed as to offset the benefit to the reserved area.

Deferred grazing has been applied on national forest range in the West so widely and for so many years that the good results to both stock and range are indisputable. Improvement is invariably rapid where there remains a fair stand of seed plants. Naturally considerable time is required to increase appreciably the forage cover on lands which for many years have been in a low state of productivity, and especially on those which support few highly palatable seed plants. Without the adoption of some grazing plan, however, such as deferring the cropping until the seed of the more desirable palatable vegetation has matured, or decreasing materially the number of livestock formerly grazed, or actually removing the animals for a year or more, there is little chance of increasing the range returns from badly depleted lands, of controlling erosion, or of improving the efficiency of important watersheds in one way or another. Any kind of plant cover is preferable to denudation or to the production of a growth so sparse that the fertility of the soil tends to decline rather than improve.

Sarvis, J. T. 1923. Effects of Different Systems and Intensities of Grazing Upon the Native Vegetation at the Northern Great Plains Field Station. USDA Bulletin 1170, 45 pages, illustrated.

The cooperative grazing experiment reported upon in this bulletin was established at the Northern Great Plains Field Station near Mandan, North Dakota, in 1915. Its objects were to determine the grazing capacity of the native range and the effects of different systems and intensities of grazing upon the native vegetation.

The experiment is conducted with four pastures under a system of continuous grazing. These pastures vary in size from 100 to 30 acres. A pasture of 70 acres conducted under a system of deferred and rotation grazing was added in 1918.

The land used for the experiment is not materially different than other vast areas in western North Dakota. This land, however, is better than would ordinarily be used for grazing. It is well adapted for experimental purposes because of its uniformity.

Early seasonal precipitation exerts a greater influence upon the production of native forage than upon other crops.

The deferred and rotation system of grazing is designed to allow different divisions of the pasture to mature a crop normally before it is grazed. Under this arrangement, a greater utilization of the vegetation is obtained with less injury to it than in any other pasture and with the greatest total gain.

The grazing season for this experiment is five months during the summer. Winter grazing is not taken into consideration -- not recommended for this section except under very unusual conditions.

The cattle used in the experiment are 2-year-old grade steers. They are weighed individually at 30-day intervals throughout the season.

The cattle have made average gains per head ranging from 294 pounds in the 70-acre pasture to 180 pounds in the 30-acre pasture. A high gain per head does not produce the largest gain per acre. A gain per head higher than the small pastures but lower than the large pastures is produced on the deferred and rotation pasture. The total gain per acre in the rotation pasture has been higher than in any of the others since the number of cattle has been increased.

The quantity of the foliage cover annually removed by grazing varies on the average from 51 percent in the 100-acre pasture to 98 percent in the 30-acre pasture. In order to avoid injury to the vegetation under a system of continuous grazing, from 15 to 25 percent of the foliage

cover must remain on the pasture at the close of the grazing season. A greater utilization of it may be made under the system of deferred and rotation grazing.

The most efficient system of grazing is one that will insure sufficient forage during the entire season to produce the greatest total gain in weight with the least number of cattle on the minimum unit of land without permanent injury to the native vegetation. The requirements of this measure of grazing efficiency are most nearly fulfilled by the deferred and rotation system of grazing.

Botanical studies in connection with the grazing experiment are necessary in order to determine the effect of different systems and intensities of grazing upon the native vegetation.

The vegetation has a total basal cover of approximately 60 percent. Of the basal cover, 20 percent is made up of *Bouteloua gracilis*, 10 percent of *Stipa comata*, and 30 percent of other vegetation. The dominant species are *Bouteloua gracilis*, *Stipa comata*, *Carex filifolia*, and *C heliophila*.

As the vegetation is the "climax" type, having the highest development, the grazing should be adjusted as to maintain it without deterioration.

The mapped quadrats used in these experiments are of value in securing a permanent record of the composition of the native vegetation. They also indicate the effects of grazing upon species that grow in mats or small bunches. From these maps it is clear that the quantity of *Stipa comata* has been reduced by the overgrazing in the 30-acre pasture.

The list quadrats used in these experiments are of great value in keeping a record of the number of plants of different species. These quadrats show that *Artemisia frigida* has increased in extent under the heavy grazing in the 30-acre pasture. The vigor of the individual plants of this species has been favored by the reduction of the competition of other species in the small pasture.

The clipped quadrats used in the experiment were designed to facilitate the study of the effects of frequent and infrequent removal of the vegetation upon its subsequent growth and also to determine the period of greatest growth. In the frequently clipped quadrats, *Stipa comata* has disappeared, other species have been weakened, and the total production has been reduced. *Bouteloua gracilis* is the one species that appears to respond to frequent clippings better than any other species. The greatest growth of the vegetation occurs early in the season at the time the cattle make their greatest gains.

Photographs of the plants growing in the different pastures have been taken from the same points each year. These form permanent authentic records that cannot be obtained in any other way.

Areas known as "isolation transects" were set aside in the 100-acre and 30-acre pastures and in one division of the rotation pasture. Units are annually closed to grazing on one side of the transect and opened to grazing on the other, while the central units are never grazed. The units that are annually closed to grazing in the 30-acre pasture contain about five times as many plants of _Artemisia frigida_ as those that are never grazed. The plants of this species are also more vigorous in the units closed in 1920 and 1921 than in those closed previous to 1920.

General field notes are kept each year upon 27 different species of plants that are common on the prairie. These notes show that the prairie has turned green in the spring as early as April 15 and as late as May 20, while it has started to "dry up" as early as June 15.

A mowing experiment was undertaken to determine the effects of the annual and biennial removal of the vegetation upon the total production. The yields also furnish data from which the quantity of forage available for grazing may be determined.

Field germination tests show that the weeds of many of the most valuable range grasses are low in vitality.

Each year a number of trials have been made to grow cultivated forage plants sown in the native sod without breaking. The results show that it is almost impossible to get the plants to grow in a vegetation of such density.

Soil-moisture determinations show that the first foot of soil in all pastures is well filled with water at the beginning of each season. It was not until 1919 that the moisture of the sixth foot of soil was greatly reduced. The sixth foot of soil in the 30-acre pasture has not been reduced to the same degree as in the other pastures.

The grasses of this region make up about 50 percent of the dry weight of all species of plants. It is estimated that 90 percent of them are palatable and therefore afford excellent grazing for cattle.

Boutelous gracilis and _Andropogon furcatus_ are the most palatable grasses, while _Artemisia frigida_ is the least palatable of all species of plants. Cattle do not like it and will not eat it unless forced to do so because of the shortage of other feed.

Native pastures deteriorate when grazed because of (1) too early grazing in the spring, (2) continuous grazing, and (3) overgrazing. All of these factors can be controlled.

The grazing capacity of the native vegetation of the area included in these experiments is shown by the results in the several pastures. The 100-acre pasture, grazed at the rate of one steer to 10 acres, is larger than is necessary to produce the maximum gains per head. This pasture is undergrazed. The 70-acre pasture, grazed at the rate of

one steer to 7 acres, provides approximately the area of land required to produce the maximum gains per head under a system of continuous grazing. The 50-acre pasture, grazed at the rate of one steer to 5 acres, is not large enough to allow the cattle to make maximum gains per head. This pasture is overgrazed. The 30-acre pasture, grazed at the rate of one steer to 3 acres, is not large enough to carry the cattle for five months. This pasture is severely overgrazed. Under a system of deferred and rotation grazing, the number of acres required per head is reduced to between 4 and 5. This acreage will provide enough feed to allow the cattle to make gains per head intermediate between those made in the 50-acre pasture and those made in the 70-acre and 100-acre pastures. This system allows the maximum utilization of the vegetation without the injury to it accompanying overgrazing.

Sarvis, J. T. 1941. Grazing Investigations on the Northern Great Plains. North Dakota Agricultural College, Agricultural Experiment Station, Bulletin No. 308, 110 pages, illustrated.

The land where the pastures are located is about 3.5 miles south of Mandan along State Highway No. 6. It is part of the area locally known as the Custer Flats. The altitude is approximately 200 feet higher than the field station, or nearly 1,950 feet above sea level. Originally it was a school section, and for a number of years previous to 1915 it had been used for the production of native hay. It was in excellent condition for grazing when acquired in trade for other Government land by the United States Department of Agriculture. The density of the vegetation was high. The experiment was therefore started on a range in a high state of production. The problem was to determine the best method of utilizing a good stand of forage. In order to study the effects of overgrazing, it was necessary first to reduce or deplete the existing vegetation.

The long-time average of precipitation for this vicinity has been 16.40 inches for the 66 years of record. The average when the station started was 17.41 inches. Since the grazing experiment started in 1916, the average for the 25 years has been 14.47 inches.

The basic plan of the grazing experiment as outlined in 1915 has been continued during the 25 years with some additions and modifications. Four of the native pastures follow the system of continuous grazing. The cattle have access to the same area during the whole season. These pastures are 100, 70, 50, and 30 acres in size and were grazed at the rate of 10 steers to each pasture or one steer to 10, 7, 5, and 3 acres, respectively. Different intensities of grazing were obtained by a variation in the size of the pastures rather than in the number of cattle grazed per pasture. It was planned to have one pasture large enough so that it would normally be undergrazed and one small enough so it would be overgrazed. The 250 acres comprising the four pastures were fenced in 1915 and grazed for approximately 115 days with 53 2-year-old steers. The cross fences between the various pastures were constructed during the fall of 1915, and grazing of the pastures started in the spring of 1916. The four pastures have, therefore, been grazed under the continuous system for 25 seasons, from 1916 to 1940, inclusive, except as later described.

In order to overcome to a marked extent the disadvantages of continuous grazing, a "deferred and rotation" system of grazing was added. This system of grazing was put into effect by the addition of a 70-acre "rotation pasture" in 1918. Rotation grazing was not new when this experiment started, as it was discussed at least as early as 1895.

It was desired to compare the grazing value of some cultivated pasture plants with native vegetation. In 1921 a field of bromegrass was established adjoining the pastures. A 10-acre tract of the bromegrass was broken in the fall of 1924 and seeded to sweetclover in the spring of 1925. Crested wheatgrass came into prominence as a grass well adapted to the northern plains, and 7 acres of bromegrass were broken in the fall of 1931 and seeded to crested wheatgrass in the spring of 1932. Other cultivated pastures have been added since that time and are described later.

The pasture designated as the "reserve" is used to carry the cattle before the experiment opens in the spring and after it closes in the fall. It is also used to carry extra steers during the grazing season. These are held in reserve for use in case of accident to any of those in the regular pastures.

The period of grazing was set for 5 months during the season from the middle of May to the middle of October. The grazing season opened May 11 in 1939; May 21 in 1921, 1922, 1930, and 1938; May 26 in 1917, 1923, 1924, 1936, and 1937; at the beginning of June in 1916, 1919, 1920, and 1935; all other years the opening date was May 16. The opening date was set near the middle of May in order to avoid so far as possible the damage caused by early spring grazing. The average date of opening has been May 20 and the closing date approximately October 18. During this period the native vegetation makes its active growth and the livestock make their greatest increase in weight. Winter grazing is not taken into consideration in this experiment.

The 70-acre deferred and rotation pasture was established in 1917 and first grazed in 1918. It has been grazed for 18 years, with 2-year-old steers. After the four continuously grazed pastures were in operation, it became evident that the experiment would not be complete without the addition of another system of grazing as a matter of comparison. For the 12 years from 1918 to 1929 this pasture occupied the area where the 70-acre pasture is now located. The change in location was made in order to afford better watering facilities for the steers in the rotation pasture throughout the season.

In order for deferred and rotation grazing to appear to advantage, it must be compared with close or overgrazing. This fact is well illustrated by a study of the results obtained in the 70-acre rotation pasture and the 50-acre continuously grazed area. The rate of grazing was approximately the same in each pasture. When the rotation pasture was established, it was not known what rate of grazing would be most applicable to it. After a few years it became evident that a direct comparison with the rate in the 50-acre pasture would be highly significant.

The vegetation in the rotation pasture has not been injured to any serious extent by grazing, in contrast to the same rate of grazing in the 50-acre continuously grazed pasture. This fact is indicated by the gains of the cattle and the condition of the various grasses.

The gains of 2-year-old steers grazed in the rotation pasture are highly important. This is because they were made under a system of grazing different from that ordinarily found in general use on ranches.

The number of steers in the rotation pasture varied during the first half of the period, but the average was 14, or 1 steer to 5 acres. In 1920 the season was started with 14 head, but 2 more were added during July. The average number for the season was 15 (to the nearest whole number). The year of 1926 was one of drought. The pasture was started with 16 steers, but it soon became evident that it could not support that number more than part of the season. Early in July nine were moved to the reserve pasture. The remaining seven head completed the season on the pasture. The average number grazed for the 150 days was 10. In 1935, because of the lateness of the start of the grasses, the number of steers was reduced to 12. The average number carried for the 18 years was approximately 14, or one steer to slightly over 5 acres.

The average gains of the steers for the 18 years was 268.9 pounds per head, or 47 pounds less than the gains of the steers in the 100-acre pasture for the same period. The gain was 37.6 pounds higher than the gains in the 50-acre pasture. In 1918 and 1919 this pasture was grazed with 10 steers, the same as the other ones. The gain per head, however, was lower than in the 100 or the 70-acre pastures. This was because the cattle had to graze a short pasture toward the end of each grazing period on a given division. Since they were short of feed part of the time, they could not put on maximum gains. In comparison with the gains produced in the 50-acre pasture, they were practically equal in 1918, higher in 1919, and significantly higher in 9 of the other 15 years. The gains of the steers in the 50-acre pasture were never significantly higher with the same rate of grazing than those of the rotation pasture, except in 1932 which was a favorable season and when the steers in the 50-acre pasture received 1.7 pounds per head of cottonseed cake daily. The gain per acre averaged higher for the 18 years in the rotation pasture than in the 50-acre area. This is an example where a comparison of gains per acre is of value, because the rate of grazing was the same. In the 30-acre pasture the gain per acre was practically equal to that in the rotation pasture, but the gain per head was more than 100 pounds lower.

It is of interest to note that the gains in October were somewhat better in the rotation pasture than in the 70-acre pasture. There was, however, a loss three times in September compared to one minor loss for the 70-acre pasture.

The fact that the rotation pasture was started 2 years later than the others did not allow it to average quite so long a grazing season. The small difference is of minor importance over the series of years.

Another comparison of significance is between the combined total gains of the 50- and the 30-acre pastures and those of the rotation pasture. There was 30 percent less cattle in the rotation pasture, but their total gain was less than 4 percent below the total for the two smaller pastures. The gain per head was approximately 73 pounds more in the rotation pasture, on 87.5 percent as much land as the 80 acres of the two smaller pastures.

The foliage cover removed by grazing with 2-year-old steers after the number was increased averaged 92 percent. The range was from 87 percent in 1924, 1927, 1931, and 1935 to 100 percent in 1934. The averages for each division was 92 percent in A and B and 93 percent in C. In 1934 each division was grazed 100 percent.

This period is too short to establish average gains of yearling steers that might be normally expected. The gains in this pasture are highly significant, because they are less in 3 of the 4 years of comparison than those of the smaller pastures. The fact that the smaller pastures were not grazed in 1935 provided them with a greater supply of forage in 1936, when little new feed was produced. Plenty of feed remained in the divisions of the rotation pasture at the close of the seasons of 1938, 1939, and 1940. The steers had plenty of feed before them at all times, but they failed to put on gains equal to those in the other native pastures. The only explanation so far as it was possible to observe or determine was that yearling steers are more reluctant to travel than are 2-year olds. It was clearly discernible that grazing was heavier nearer the watering trough. The yearlings seemed to prefer to graze a short pasture rather than to travel to the far side of it. Salt was placed at the far side of the divisions, but this did not alter the results. In the case of 2-year olds the divisions were always grazed uniformly.

The foliage cover removed by grazing with yearling steers averaged 72 percent. The range was from 57 percent in 1939 to 93 percent in 1936. For the 3 years 1938-40 the average was 62 percent.

Shepperd, J. H. 1933. Wait Until Pasture Is Ready. Country Gentleman, 105(3):54.

It is a great temptation to turn livestock to pasture before the grass has growth enough to warrant it. A pasture which is grazed too closely in early spring will not make a reasonable yield at any time during the later season, and the bad effect often carries on in subsequent years.

Allowing grass to get a reasonable good growth of blades adds to its strength to a surprising degree. At Mandan, North Dakota, in a pasture trial it was found that allowing one-third of a native wildgrass pasture of seventy acres to rest -- that is, go without grazing until late in July -- one-third of the years, makes it strong enough to carry 40 percent more two-year-old steers than the seventy-acre pasture beside it.

Sweetclover plants should be six to eight inches high before grazing is started. It is not necessary to hold the growth back to that height while being pastured by means of heavy grazing or by clipping, as many have guessed. Cattle, horses, and sheep graze it with great satisfaction and good results after it has blossomed and started to form seed.

Sweetclover pasture can often be used for early spring grazing while the grass is getting a start in the grass pastures. With the prairie grass at Mandan, we have found that a sweetclover pasture of small proportion which can be grazed heavily during May, June, and the first half of July can be used to rest a prairie pasture and relieve one of the cost of fencing the prairie-grass field into three separate pastures.

Shepperd, J. H. 1939. The Mandan Grazing Trial. North Dakota Agricultural Experiment Station Bimonthly Bulletin (III)1:7-9.

Sixteen hundred fifty-four head of cattle have told their grazing stories in yield and quality of flesh during the past 24 years on the trial pastures 3½ miles due south of Mandan, North Dakota.

Range or so called "wild steers" are used in these trials and the cattle are grazed for a period of 150 days.

They are started on the pasture when the grass is considered "ready," which has been somewhere between the tenth and twentieth of May according to the season. A reserve pasture is provided and the cattle are grazed in it for 10 days or more so as to get them accustomed to the pasture and the general surroundings before the trial is started.

Thirty, 50, 70, and 100-acre pastures were fenced so as to corner up at a common watering place where small corrals, shelter sheds (open to the south), a cutting chute, a scale, and a squeeze for branding were provided. Ten 2-year-old steers of as nearly the same type and size as possible were placed in each pasture and a safety group carried in a reserve pasture for use as substitute beasts, in case anything should happen to a trial lot steer to incapacitate him. Lightning has struck them, a wire staple in a foot, a severe case of lumpy jaw and one or two cases of digestive tract disorders have forced their removal. Few troubles overtake a hardy steer of 2 years and a reserve steer that has been weighed on each monthly weigh day. It will be noted that with 10 steer lots grazing 30, 50, 70, and 100-acre pastures we supply 3, 5, 7, and 10 acres of grazing per 2-year-old steer.

Three and 5 acres were not sufficient to carry a beast through the season while 7 acres seemed to carry a steer as well as 10 acres a head did. As soon as this was ascertained, a 70-acre pasture adjoining the original 7 acres to the steer pasture was fenced and cross fenced into three divisions of 23-1/3 acres each. It was the design of this study to learn what effect allowing the wild grasses to make their full growth for 2 years in succession would have upon their carrying capacity. The plan adopted was as follows: Division A was allowed to grow without grazing until its grass was fully mature (late July) for 2 years in succession after which the cattle grazed it off. Division B was allowed to make its full growth in like manner for the next two years and was then grazed off. Division C was left to make its full growth the third 2 years and was then pastured off by the cattle. The result was that 14 two-year-old steers were necessary to graze it down instead of ten head and that each steer made nearly as much average gain per head and per season as the 10 did that were allowed to graze over the entire area during the whole season. The grass cover was not injured. Here was 70 acres doing the work of 98 acres. Just how it did this may be debatable. It has been found by trial that blue grass clipped with a lawn mower once a week yields only 50 to 65 percent as much dry matter as the same grass beside it will yield if allowed to grow to the heading stage.

Smith, Jared G. 1895. Forage Conditions of the Prairie Region. USDA, Yearbook of Agriculture - 1895, pp. 309-324. illus.

There are in the valley of the Mississippi and its tributaries more than 500,000,000 acres of prairies, covered with the characteristic black alluvial soil. It is the largest compact body of agricultural lands in all the world.

All plains regions, because of their physical configuration, are subject to great and sudden changes of temperature, there being nothing to break the force or alter the direction of the powerful winds that continually sweep over them. But lying, as our Western prairies do, entirely within the temperate zone, the conditions of existence are better there than in any other similar region.

The prairies in their wild state were covered with the richest possible grass flora. There was no similar region that had so many useful species and so few poisonous or injurious ones. Almost any square mile of the whole extent of territory could furnish in one season 50 kinds of grasses and native forage plants, grasses that would make from one and a half to two tons of hay per acre as rich as that from an Old World meadow. It was a magnificent legacy to the rancher and the farmer. To the one it promised food for a million cattle; to the other it proved the golden possibilities of a soil that would bring forth bountiful harvests. But within the last thirty years all this has changed. We can no longer point to our broad prairies and say that the natural forage conditions here are the best in the world. Hardly an acre remains anywhere east of the ninety-seventh meridian that will still yield its ton and a half of prairie hay.

The amount of water that the arid prairies receive would be sufficient if it were distributed uniformly through the winter and the growing season, or if it came in drizzling showers so that it would all be absorbed; but it usually comes in sudden torrents. A small amount is caught and held by the soil, and a larger amount is carried away by the streams. The arid and semiarid lands vary from 1,500 to 8,000 feet in elevation. They were originally covered with a turf composed of buffalo, grama, mesquite, blue stem, and wild-wheat grasses, that formed an excellent natural pasture for the immense herds of buffalo, elk, and antelope, and later for the ranch cattle. These lands can not be called agricultural. True, they have a rich soil and will yield bountiful crops under irrigation or in good seasons when the rainfall is properly distributed, but so long as these conditions are beyond control and can not be supplied the lands do not and will not compete with those of the more humid regions farther east.

The close buffalo grass or grama sod sheds water as well as a shingle roof. The surface soil may become moist to the depth of 2 or 3 or 4 feet beneath such a sod: then for a great depth the subsoil is absolutely dry down to the water table, or point at which water may be obtained in

wells. This was the condition of the plains of eastern Colorado at the time the first irrigation ditches were constructed, twenty years ago, and the same condition of affairs exists today through the whole arid region.

If it were desired to change western Kansas and Nebraska from a grazing to a farming region, the most practicable way would be to break up every acre of the prairie sod to enable the ground to absorb more of the annual precipitation. If this were to be done, it would take perhaps ten years to saturate the subsoil to a sufficient depth. Such a course would be neither practicable nor desirable, as there is already too much land available for growing cereals. These high arid and semiarid prairies are fine grazing lands, and will continue so for many years if they are properly treated.

The yield of wild hay in the prairie region is far from uniform, depending as it does upon the amount and distribution of rainfall through the growing season. Hay meadows that are cut continuously for a number of years deteriorate rapidly, both as to yield and quality of hay. The latter depends upon the relative amount of weeds that the hay contains.

Wild meadows are not given the same treatment as tame meadows. They are neither reseeded by the farmer nor allowed to reseed themselves. The natural result is that the vitality of the grasses is diminished and they are unable to hold their own against the weedy perennials that are so abundant in all prairies. These weeds increase so rapidly that they soon gain the upper hand and become more numerous than the grasses, and the meadow loses its value as hay land.

The price of good prairie hay varies from $2.50 to $10 per ton, baled, at the railroad, according as the visible supply of hay varies throughout the United States.

With such yearly yields, and at such prices, it will pay to improve the prairie meadows, so that the product shall not decrease in amount or deteriorate in quality. The wild hay grasses should be permitted to reseed themselves, if not one year in three, at least one in four or five.

The prairies in their natural state were covered with an exceedingly rich grass flora. They were superb grazing grounds, clothed from early spring to late autumn with a succession of the most nutritious grasses, and in winter with standing hay as good as or better than tame hay. Forage was plentiful and cheap--to be had for the cost of gathering it. The early settler saw no need of cultivating grasses and clovers, for was there not at his very door better pasture and better hay land than he could get with his timothy and clover in many years at much labor and expense? Those who are interested in better forage conditions for the

prairie States have continually to face this argument, even in sections where the best native grasses have been all but exterminated. Farmers in the West say that prairie hay is better and cheaper than tame hay, and if cattle will live through a winter on what they can pick up from the prairies, what is the use of planting all these forage crops? Such has undoubtedly been the state of affairs over the entire region, but it can not last much longer, and if we want to be forehanded and prevent the great losses of livestock that occur every time there is a bad season, we must take time by the forelock.

Thus we see that the problem of improved forage conditions in the prairie region, whether looked at from the standpoint of the farmer or from that of the stockman, centers upon the one question, Shall we plant grasses? To this there can be but the one answer: As the cultivation of grasses and forage plants is at the foundation of agriculture, if we are to improve the quality of our farming lands and increase their capacity for production, we must devote more acres to grass. It is absolutely necessary to impress this fact upon the intelligent and progressive farmer.

There has been much written and said within the last ten years about the deterioration of the ranges. Cattlemen say that the grasses are not what they used to be, that the valuable perennial species are disappearing, and that their place is being taken by less nutritious annuals. This is true in a very marked degree in many sections of the grazing country.

The one great mistake in the treatment of the cattle ranges, the one which always proves most disastrous from a financial standpoint, is overstocking. It is something which must always be guarded against. The maximum number of cattle that can safely be carried on any square mile of territory is the number that the land will support during a poor season. Whenever this rule is ignored there is bound to be loss. The present shortage of cattle all through the West is due to the fact that the ranges were stocked up to the limit that they would carry during the series of exceptionally favorable grass years preceding the years of drought. Then followed a series of bad years, when the native perennial grasses did not get rain enough to more than keep them alive. The cattle on the breeding grounds of the West and Southwest died by thousands from thirst and starvation. It may seem like throwing away money not to have all the grass eaten down, but in the long run there will be more profit if there are fewer head carried per square mile.

The most nutritious grasses are not the annuals, which live only just long enough to produce seed and then die, but the perennial ones, which store up in their stems and running rootstocks quantities of starch and gums and sugars, to be used by the plant when growth commences, at the end of the winter, or dormant, period.

Clearly then if the grazing quality of the ranges is to be improved, they must be so treated that the nutritious native species of grasses and forage plants can spread by means of the ripened seed. This can be accomplished by dividing the range up into separate pastures and

grazing the different fields in rotation. There is a constant succession of species that ripen their seed from June until October, commencing with Kaleria, Eatonia, Stipa, and Buchloe in June and July, and ending with Andropogon, Sporobolus, and Triodiu in October. If these grasses are killed out, their places will be taken by annuals of weedy proclivities, such as the numerous species of Eragrostis and Aristida, which are neither lasting nor nutritious; grasses that spring up with the early summer rains, ripen an abundance of seed, and die.

Smith, Jared G. 1899. Grazing Problems in the Southwest and How to Meet Them. U.S.D.A., Division of Agrostology, Bulletin #16, 47 pages, illustrated.

Less than thirty years ago 4,000,000 buffalo and countless numbers of wild horses roamed unrestricted over the region in question, gradually moving northward as the season advanced, returning southward at the approach of winter. This natural movement of the stock permitted alternation of pasturing and rest for the land, resulting in the maintenance of the forage supply; in fact it was an ideal method of fostering and improving these pasture lands which covered nearly 200,000 square miles of country.

The nature and extent of the interests here make this region an especially important one in the line of grass and forage plant investigation. The carrying capacity has diminished fully 40 percent through overstocking and bad management during the past fifteen years, and the grazing and forage problems of the region demand serious and careful attention.

There was a constant shifting of the wild herds in their search for the best pasturage, and with the season, drifting northward with the spring and southward at the approach of winter, congregating where there was water and grass. The conditions were entirely natural and the movements of the herds were almost unrestricted. The intermittent grazing and resting of the land resulting from the roving habits of the buffalo and mustangs was an ideal method of fostering and improving the natural pasturage. The result of this alternation of pastures, conducted on a gigantic scale, was that the native grasses were allowed to fully ripen their seeds, and perpetuate themselves each year in the most liberal manner.

During this intermediate decade there were fewer head of stock, wild or domestic, than at any previous period. There were also abundant rains and the seasons were mild and favorable to the full development of the grasses. Grasses and forage plants, ungrazed, grew and thrived, reseeded themselves, and increased to a wonderful degree of luxuriance, so that the stockmen on entering this pastoral paradise thought that it was not possible to put enough cattle and sheep on the land to eat down all of the rank growth of vegetation. It is the common testimony of the older stockmen that in the early eighties the grass was often as high as a cow's back, not only along the river bottoms, but also on the uplands far from the creeks and rivers.

The grazing capacity of large bodies of land has been reduced within a period of twenty years from one head to 2 to 5 acres, to one head to 20 to 25 acres. As late as 1883 from 128 to 320 head of cattle could be supported on a single section, where to support a like number now requires from 4 to 12 square miles. Where the conditions have been especially unfavorable, stockmen report that it sometimes requires 60 acres per head, and the land there is almost bare of vegetation. Such denuded areas occur in New Mexico and Arizona, and are due almost entirely to the ruthless destruction of free grass on public lands.

Unless the pasturage is fostered and these best grasses are protected by resting or by artificial care and cultivation, they are soon reduced in number and become unimportant factors. They are prevented from ripening seed and are eaten so close that often the roots are killed by exposure. The first result of overgrazing is the disappearance of the best grasses, that is, a lessening of the potential carrying capacity of the pasture. If the best grasses cover 25 percent of the range, the loss from overgrazing will be at least that amount. If the pasture is still overstocked, a similar process is continued with the remaining species until at last there is not a blade or fragment of a stem left to support any grazing animal.

For the purpose of carrying on experiments, two sections of land have been leased by this Department, one at Channing, in Hartley County, Tex., which will represent in a large measure the conditions that prevail in the high plains of the Panhandle, and one at Abilene, Tex., to serve for the central and western prairies up to the border of the Staked Plains. On each of these sections three 80-acre and two 40-acre pastures have been fenced and are being treated as follows:

Pasture No. 1. - No treatment except to keep stock off until June 1, pasturing the balance of the season.

Pasture No. 2. - Cut with a disk harrow and keep stock off until June 1, pasturing the balance of the season.

Pasture No. 5. - No treatment except pasturing until June 1, and keeping stock off the balance of the season.

Nos. 1, 2, and 5 each contain 80 acres. Pastures numbered 3 and 4, each consisting of 40 acres, are being grazed alternately, the stock being changed from one pasture to the other every two weeks. In addition to these fenced and stocked pastures, 80 acres of land were dragged with an ordinary straight-toothed iron harrow, one 80-acre tract was disked, and a third was left as a check without any treatment whatever except that, in common with the other two, no stock was allowed to run on it during the first season. The remaining 80 acres are devoted in part to the cultivation of grasses and forage plants, using both such as can be obtained in the markets, and the native sorts, while a portion has been set apart for minor experiments.

Partial resting, or resting during different seasons of the year, a system which may be designated the alternation of pastures, secures the same result at much less expense. Thus a range might be divided up into a number of small pastures provided with water, in each of which the cattle would be allowed to run for not more than two or three months at a time and then be transferred to another. In this way the succession of grasses which normally occurs in nature can be fostered and improved.

It is also claimed that pasture land thus treated will carry more head of cattle through the year and bring them out in better condition than where the herd has access at all seasons of the year to all portions of the range. Where winter feeding is practiced in connection with alternation of pastures, the very best results may be obtained at the least cost, and the owner will find that with judicious care the value of his property will constantly increase and the annual profit as represented by the increased number of marketable steers will more than compensate for the cost and labor of changing cattle from one pasture to another.

Smoliak, S. 1960. Effects of deferred-rotation and continuous grazing on yearling steer gains and shortgrass vegetation of southeastern Alberta. Jour. of Range Mgt. 13(5):239-243.

The grazing trial was conducted during the years 1949 to 1957 with a grazing season of six months (averaging May 1 to October 27). Two 300-acre fields were used. One field was grazed continuously for six months each year. The adjacent field was subdivided into two equal rotation fields A and B and each rotation field was grazed for one and one-half months in the spring and one and one-half months in the fall every other year and for three months during the summer grazing period in alternate years.

Ten head of grade yearling Hereford steers were used in each of the two pasture systems in 1949 and 1950. From 1951 to 1957, inclusive, 16 yearling steers were used yearly on each pasture, giving a stocking rate of about 19 acres per yearling steer for the six-months' grazing season.

Total annual precipitation for the period averaged 13.8 inches and the April to July, inclusive, precipitation averaged 7.1 inches. Principal forage species were blue grama grass, needleandthread grass, Junegrass, and western wheatgrass.

The total grass and sedge ground cover increased slightly more on the rotation fields than on the continuously grazed fields, but the difference was not significant.

Although average production of forage on the rotation fields was greater than on the continuously grazed field, the difference was not significant.

Average estimates of forage utilization over the nine-year period on the rotation and continuously grazed pastures were 46 and 44 percent respectively.

Herbage clipped from the continuous pasture during the summer and fall contained significantly more protein than herbage from the rotation pasture in 5 out of 6 years.

There was a highly significant difference in the total seasonal gain made by steers in favor of continuous grazing in all years but one.

Under continuous grazing cattle have access to each plant species when it is most palatable and nutritious. With deferred-rotational grazing the grasses become too coarse to be effectively utilized towards the end of the season.

Springfield, H. W. 1963. Size of Grazing Area Affects Sheep Behavior. Western Livestock Journal 41 (36): 46-47.

The study was conducted in 1958 and 1959 on small areas of seeded crested wheatgrass used as lambing range in Northern New Mexico.

Twelve 5-acre paddocks stocked at four levels ranging from 2.2 to 5.8 sheep months per acre were stocked with pregnant ewes and grazed during the lambing period. A 200-acre fenced range surrounding the paddocks was stocked with pregnant ewes from the same herd and grazed at the same time. The ewes, 2-6-year-old Rambouillets, were allowed to graze freely without herding. Water and salt were available at all times.

Activities of the sheep were somewhat more clearly defined in 1958 than in 1959. Drier conditions in 1959 may account for the substantially higher number of sheep observed grazing from 7 to 9 a.m., 11 a.m. to 2 p.m., and 4 to 6 p.m. Likewise, more sheep were observed browsing shrubs from 7 a.m. to 4 p.m. in 1959. The principal rest period was from 7 a.m. to 2 p.m.

Stocking rate also appeared to affect sheep grazing habits. In 1958 ewes grazed longer and more frequently within paddocks stocked at 5.8 sheep-months per acre than in those stocked at 2.2 sheep-months per acre. The difference in time spent grazing was particularly noticeable from 7 to 11 a.m. Most ewes within lightly stocked paddocks obtained their fill by 7 a.m. whereas those in more heavily stocked paddocks had to graze longer because forage was less plentiful.

Restriction of sheep within small paddocks also apparently influenced their activities. Inside the paddocks they had a tendency to rest in small groups along the fence. Later in the day from 3 to 4:15 p.m. the percentage of sheep grazing was about the same under both situations. Sheep traveled less and rested more inside the paddocks within the larger fenced area both during the morning and afternoon. Also, sheep in the 200-acre area appeared at water more frequently throughout the day than those in paddocks.

Stoddart, Laurence A. 1945. Range Land of America and Some Research on Its Management. Utah State Agricultural College, Fourth Annual Faculty Research Lecture, Logan, Utah. 32 pages.

Although grazing of livestock has been a practice and a profession of man almost from his beginning only recently has range management reached anything approaching a precise science. Although trials and errors over the years brought to light much practical methodology for assuring high production from grazing land, still it remained for the plant physiologist and ecologist to find the whys and wherefores, and to advance new methods and new thoughts which promise to increase productivity still further and at the same time maintain the great range resource.

The peculiar land situation that marked America in her formative years had much to do with the philosophy of early livestock growers. To understand this philosophy, we must remember the freedom and the vastness of frontier America. Grazers owned little or no land and their movements were known to few and questioned by none. The plentiful forage is evidenced now by words of early adventurers, as Fremont's "...tremendous areas of luxuriant grass - an inexhaustible supply;" Lewis and Clark's "These western ranges have a luxuriant grass cover and will supply enough feed for all the cows in all the world;" and Bradley's "...good, find grasses grow evenly all over the country - I believe that all the flocks and herds in the world could find ample pasturage (here)." Herdsmen rested secure in the knowledge that over the next ridge was more feed free to the first comer.

As in all parallel situations, the very plenty of the range induced lack of appreciation of its value. There resulted an almost complete disregard for conservation. This feeling was seriously aggravated by the federal government's land policy which allowed free use of the vast majority of the public lands without supervision or control. As competition increased and the land became more and more fully used, the free-use policy encouraged the man who got there first, who brought the most animals, or who grazed the closest. No benefit could possibly result from conservative use; indeed, such practice was fraught with danger since good feed encouraged the encroachment of neighboring herdsmen. Misuse, resulting primarily from overuse, was the natural result, especially on public lands.

Overuse was furthered by the fact that America's early-day ranchers were often old-world farmers accustomed to highly productive land. As these immigrants and the eastern farmers migrated westward they met increasingly arid land - land whose limitations and whose management they little understood. Only in recent years has the inherently low production of the western range been generally understood. This is evidenced not alone by the prevalence of range overuse but by the whole history and philosophy behind the settlement of the West. Again,

federal land policy has erred. The Federal homestead laws generally limiting the acreage available to individual ranchers to 320 acres or, at best, to 640 acres demonstrate lack of understanding of the West even among leaders of the government. The maximum acreage allowed was but a tenth of that necessary for an economic livestock production, and such limitation was an inevitable stimulus to overuse of the land.

The technical science of range management developed among federal land administrators, mostly from the Forest Service, beginning about 1905, and later from the Grazing Service, beginning in 1934. These men, charged as they were with conserving the nation's lands, based the science on conservation of range resources. Range lands, which these agencies were ordered to administer, are known to have been in a condition far inferior to that which the ecologist could expect from natural conditions existent, primarily climate and soil. Indeed, the situation, at least locally, was such as to cause immediate alarm. A fortunate result was the initiation of range research chiefly through the establishment of forest and range experiment stations by the Forest Service and to a lesser extent through the Bureau of Plant Industry, the Bureau of Animal Industry, and the state agricultural experiment stations. It seems apparent also, however, that in the formative years of the science there was an unfortunate emphasis placed upon conservation at the expense of production. The difference in emphasis is perhaps one of viewpoint or philosophy rather than face for the concordance of range conservation and range production is immediately evident even to the uninformed. Nonetheless, stockmen have felt keenly and have openly resented the lack of production emphasis on the part of range management technicians.

Technical range management to be valuable to livestock growers must be practical. It must be founded upon common sense and sound economics. Surely long-time economical range livestock production can be based only upon conservation of the range land upon which the industry is dependent. Range land is of value to mankind only when it can be made to produce. Inevitably then, range conservation finds its justification only in maintenance of production. This suggests the following as a definition of range management. Range management is the science of planning and directing range use so as to obtain the maximum livestock production consistent with conservation of the range resource and economic balance of the livestock industry.

Care must be exercised in interpreting this definition because conservation of range land should be considered only in terms of long-time periods involving cycles of weather and sometimes slow improvement or deterioration of soil. Greatest immediate production from the range unquestionably comes from overuse through large numbers of livestock, producing as a result of limited feed supply not the greatest amount of meat or wool per animal, but nonetheless, the greatest amount per acre of land. Technical range management then reaches its zenith in this long-time forecasting, involving intimate knowledge of the soil and its stability and of the plants which bind the soil and feed the animals. As the sociologist and the physician prevent, diagnose, and cure the ills of mankind, so should the range ecologist understand the delicate balance

which nature maintains between the soil, the plant which it supports, and the animal which the plant feeds.

So should he know the ability of soil and plant complex to endure grazing and trampling from livestock and know and diagnose their illnesses and prescribe their cure. The complexity of such a science is at once apparent for it involves careful application and correlation of soil science, botany, and animal husbandry, all of which must be guided by the practical requirements of good economics.

Further complexity is introduced by the requirement that land utilization must be understood and correlated with the demands of mankind. This is an era of multiple use of land - a use which involves correlation between all interests concerned with the land. Range lands depend upon farm land for stability and balance; use of the two must be correlated. Non-farmed land is used by domestic animals but it also supports game and wildlife of all forms, even fishes. It yields timber, minerals, and water. The gathering and controlled liberation of water is perhaps the most important yet least understood of all functions of western land. Much of the mountainous range is the watershed from which comes the water for culinary purposes, power, and irrigation - water which is the very lifeblood of civilization, industry, and agriculture. Maintaining watershed stability is a fundamental part of intelligent range management.

Broad understanding of the economic and scientific relationships between these many industries and interests has led to multiple land use over much of the West. The thought that range management is for the benefit of the livestock industry alone represents a narrow viewpoint. Over a very large percentage of the range land, livestock production is not the sole consideration or interest of the range manager. Economic balance between range livestock interest and the many other interests of the land must be given careful attention and study to insure the greatest benefit to humanity from its greatest resource - the land.

The western range is not a land having peculiar adaptation to the production of livestock, but rather it is the residue resulting from an era of settlement during which land adapted to cultivation or other more intensive uses was removed from range use. Although peculiarly well adapted to grazing use, actually this residue remains as livestock range because it is physically or economically unsuited to other forms of production. Its limited use results in many cases from alkaline, shallow, or stony soils; from steep and rugged topography; or from distance from markets, transportation facilities, and centers of population. However, by far the most important factor limiting the land to use as livestock range is climate, specifically, low precipitation. About one-fifth of the western range receives an annual precipitation of less than 10 inches and almost half receives less than 15 inches, the approximate lower limit of successful dry land farming. Most of the land receiving precipitation about 20 inches per year is mountainous, hence farming is prohibited by topography. Valleys of rich and relatively level land must be farmed largely through irrigation and their production must be correlated in large measure with the demands of range livestock which graze adjacent lands.

Sylvester, Donell D. 1957. Response of Sandhill Vegetation to Deferred Grazing. Jour. of Range Mgt. 10(6):267-268. Illus.

The 2,240-acre Waddill ranch is located approximately 12 miles northeast of Gordon, Nebraska, in the sandhills of western Cherry County. The 18-19 inches of average annual precipitation rapidly infiltrates into the sands.

Three hundred and thirty acres of subirrigated meadows are used for hay. The 1,900 acres of hills are used for grazing during summer and snow-free winter months. If closely grazed, the dune sand begins to move with the wind. Grass is the natural stabilizing force for these sands.

In the fall of 1949 the normally vigorous sandhill grasses -- sand bluestem, sand lovegrass, prairie sandreed, and little bluestem -- had given way to shorter species -- hairy and blue grama and the less palatable green sagewort and sandhill muhly. The forage production of the pastures had decreased due to heavy grazing, and the beef production was down.

Among the first actions was the negotiation of a five-year lease to summer 210 cows and their calves. This made it possible to rest all the home range in the summer of 1950 except one pasture. By fall Waddill was pleased to see areas with plant cover that had been bare the previous winter.

In January of 1951 Waddill wrote, "As winter progresses, we are all the more convinced that this deferment program is the thing. Last year at this time we found it necessary to bring in from the cow herd the thin cows and heifers that had been on hay five to six weeks and put them on cake."

After the second summer of deferment, an observer could see increased coverage from the remnants of sand bluestem and sand lovegrass. Both were displacing less desirable vegetation.

March 1953 -- "Our cattle have steadily grown more rugged and thrifty, including the calves. Our calf crop is approximately 95 percent. Our top load of steer calves weighed 445 pounds in 1951 and 444 pounds in 1952. We are happy with the recovery of the grass in our pastures."

Today (1957) the ranges are well covered with high producing grasses. Beef production is up. Sand bluestem, sand lovegrass, and prairie sandreed have crowded out most of the sandhill muhly, green sagewort and shorter grama.

Mr. Waddill says, "Never again will I graze the hills as I did prior to this program. I want those good grasses."

Talbot, M. W. 1961. The 40-Year Story of the Gila River Grazing Capacity Test Area. Abstracts of papers presented at the 14th Annual Meeting, ASRM, p. 40.

A tract of privately owned, semi-arid grassland on the Woodrow Ranch in western New Mexico was fenced from "open range" in 1913 and has been grazed continuously by cattle since 1915. This tract became the Gila River Grazing Capacity Test Area. The data reviewed in this paper was derived from initial mapping of the tract by the author in 1918, his reexamination and remapping in 1958, interim records by four other trained observers, and information furnished periodically by the ranch owners.

Dramatic changes over the 40-year period include: thinning of perennial herbaceous forage plants to less than half their density in 1918, detectable but erratic increases in annual plants, and conspicuous and continuing invasion of unwanted shrubs. Most of the heavy loss in grazing capacity occurred during the first 8 years of the test, overall changes since 1926 have been slow. However, the relative stability during the past 30 years has been at a lower level of production than the one which characterized the site before the "break."

The unique records of this early study help explain why there continues to be much honest doubt about the magnitude of past losses to the forage resource and about the failure of most damaged ranges fully to regain top production when good rains come again. It is concluded that the cumulative impact of continuous heavy grazing and periodic adverse weather cannot be overcome by reduction in livestock numbers alone. A system of grazing is needed that will insure periodic rest to restore and maintain the vigor of weakened grasses. Shrub control and other costly measures are now required on many ranges where the trend of condition is downward if attainment of the potential productivity of the site is the aim of management. For this reason alone, the facts derived from this 40-year study should comprise an added and very cogent incentive for the continued practice of efficient conservative grazing of the semi-arid grassland type by operators whose ranges are still in good condition.

Thomas, Gerald W. and Vernon A. Young. 1954. Relation of Soils, Rainfall and Grazing Management to Vegetation - Western Edwards Plateau of Texas. Texas A&M College, Texas Agric. Exp. Sta., Bull. 786, 22 pages, illus.

Grazing experiments were initiated on the Texas Range Station in 1938 to supply information on the influence of soils, rainfall and grazing on a vegetation type common to a large area of west Texas. The station lies on a broad drainage divide of the Edwards Plateau at an elevation of 2,700 feet. The average annual precipitation at the station headquarters for the past 16 years was 16.68 inches.

The most abundant grasses are sod-forming species: buffalograss (Buchloe dactyloides), curly mesquite (Hilaria belangeri), and tobosagrass (Hilaria mutica). Species of lesser abundance are sideoats grama (Boutelous curtipendula), threeawn grasses of the Purpureae group (Aristida spp.), vine mesquite (Panicum obtusum), hairy tridens (Tridens pilosus), fall witchgrass (Leptoloma cognatum), muhly (Muhlenbergia arenacea), tumblegrass (Schedonnardus paniculatus) and hairy grama (Bouteloua hirsuta).

Since 1938 the pattern of stocking has varied. All pastures have been subjected to some grazing by both sheep and cattle. Certain pastures have been used in both rotation grazing and continuous grazing management. Stocking rates for all classes of livestock have been changed several times on each pasture during the period. The average stocking rate for the 16-year period varied from 14 to 40 acres per animal unit per year.

This variability in stocking rates, livestock classes, and seasons of grazing makes the problem of accounting for pasture differences very difficult. All of these factors have contributed to the fluctuations in vegetation. However, forage species differ in their responses to them.

It has been assumed in this study that vegetational differences between pastures were largely a result of differential grazing use. This assumption is based on the fact that the pastures were fenced in the present pattern in 1938. It is further assumed that, except for soil characteristics, the environmental complex was similar throughout the area. Rainfall and temperature measurements taken at the ranch headquarters are believed representative on the entire area.

Most grass species were more abundant on the lightly stocked pastures than on the heavily stocked pastures. Also heavy spring grazing appears to be more detrimental to most grasses than heavy fall grazing.

An apparent increase in prickly pear has occurred under yearlong and seasonal heavy stocking. The correlation coefficient, r=.522, for fall stocking rate and prickly pear is statistically significant, indicating that heavy stocking in the fall caused an increase in prickly pear.

Serious reductions in vegetational density were noted in pastures A and B under a seasonal rotation grazing system. These 172-acre pastures were stocked with 75 sheep and 10 cows for the 6-year period, 1938-43. The dates of rotation were fixed at the same time each year. As a result the vegetation in both pastures deteriorated even though rainfall conditions were favorable. Pasture A, which was grazed each year during the spring growing period, showed a serious reduction in most of the better grasses. Similar rotation grazing systems were tested on pastures I, K, L, and M. In each case the pastures that were heavily stocked during the spring growing season deteriorated faster than those stocked during the other seasons. This evidence emphasizes the importance of a systematic deferment in the rotation design so that one pasture will not be grazed during the critical spring period every year.

Thornton, Joseph F. 1960. Managing Great Basin Juniper-Sage-Bitterbrush Range Lands for Big Game and Livestock on National Forests in California. Abstracts of papers presented at the 13th Annual Meeting, ASRM, p. 59.

The Great Basin Juniper-Sage-Bitterbrush types are important feed areas for both deer and livestock. Forage is recognized as the primary value under the concept of multiple use. Management direction calls for use of both livestock and game.

Basic considerations by the range manager include:

1. The forage plant requirements to sustain and improve itself.
2. Management of livestock to minimize conflicts.
3. Control of game and livestock numbers.
4. Range improvement practices.
5. Livestock Management must be practical and economical.

Deer and livestock compete for forage in varying degrees depending upon:

1. Numbers of animals.
2. Kind of amount of available forage.
3. Distribution of animals.
4. Season of use.

There are means of minimizing these conflicts using practices and methods developed by research and range managers that include range improvement, revegetation and grazing management systems.

It is possible to graze sheep in the spring and leave most of a season's growth of bitterbrush for deer. A deferred rotation system can be practiced at the same time.

Investments are needed in fencing and water developments for deferred and rest-rotation grazing systems to continue full and continued utilization on cattle ranges. Values derived from forage can justify much greater capital investments in range improvements than we now have.

The 24,000-acre Tucker Cattle Allotment has a present estimated capacity of 3,200 cow months and 2,700 deer months. Capital investments in fences and water developments are needed to maintain that level of livestock use. Revegetation through release and reseeding of grasses and bitterbrush can double the capacity.

A rotation system of use by cattle helps minimize the conflicts between cattle and deer and allows forage plants to reseed. A flexible management system is provided that gives the range manager opportunities to adjust for yearly and seasonal variations for practical livestock management.

Udy, Lowell J. 1960. Range Improvement Through Grazing Management In the Salmon District, Idaho. Abstracts of papers presented at the 13th Annual Meeting, ASRM, pp. 51-52.

This area of Federal range is part of the Salmon District administered by the Bureau of Land Management at Salmon, Idaho. In 1949, when I first became acquainted with this area, 11 cow men and 2 sheep men were licensed for and were using this part of the Federal range with 1,635 cattle and 2,000 sheep. On the 35,000 acres of Federal range involved in the unit, the maximum season of use was April 16 to December 31, with some of the licensees making use of the Federal range for the entire season. Range management was not being practiced and each operator had the idea that if he didn't get his livestock out first his neighbor would get the feed. The cow men and sheep men were fighting over areas of use. All in all, the result was serious depletion of the soil and forage resources. A range survey was made of the area in 1941 and showed that on the spring range 17 surface acres per cow month were required. A resurvey in 1951 showed that 27 surface acres per cow month were required.

To prevent further damage to the soil and forage resources, the Bureau of Land Management initiated a reduction in Federal range use of 45 percent in either time or numbers or a combination of both by the 13 licensees involved. The reduction went into effect at the beginning of the 1953 grazing season. Also, in line with the reduction, the area was divided into one sheep and two cattle allotments.

The one group of cow men (Baldy Mountain Association) started their adjustment program. The other group of cow men (Haynes Creek Association) did not start an intensive adjustment program.

The Baldy Mountain Association agreed that, although their licenses allowed them to go on the Federal range May 1, they would not turn out until the feed was ready. As a result of this they have never turned out before May 6 and sometimes as late as May 21.

During the fall of 1952 the Bureau of Land Management reseeded approximately 600 acres in the Baldy Mountain Association area of use. This was first used in the spring of 1956 and since then has been used from 10 to 20 days each year with 367 cattle.

After the reduction this association decided that, in order to get better livestock distribution and intensify their management, additional water holes and drift fences had to be developed. Since 1953 the Bureau of Land Management has, with the cooperation of the licensees, installed 5 sets of water troughs and 4 miles of fence. The licensees, after learning how to develop springs, have installed 9 sets of troughs and built 4½ miles of drift fence.

The development of springs and drift fence has resulted in better distribution of grazing on the range.

Prior to the adjudication both sheep and cattle were on the summer range by May 15. At the present time no livestock go on the summer range before July 1. The association uses a rotation system of grazing on the summer range.

As a result of fewer grazing animals and the intensified range management practiced by the association, their cows are in better condition at the end of the grazing season; and the weight of the calves has increased on the average 35 to 40 pounds per head. The calf crop percentage has also increased.

The sheep men started to adjust their operations in order to get the maximum benefit from their allotment while the native forage was increasing. In adjusting their numbers the sheep men also changed their operation. They have developed additional water and have plans for cross fencing their area.

Prior to the adjustment the black faced lambs averaged 83 pounds. After the adjustment and change in operations and after changing from black faced to white faced sheep and also lambing 10 days later, the sheep men get more twin lambs with the lambs averaging 85 pounds.

In line with the Bureau of Land Management policy on restoring previously reduced livestock numbers either in whole or in part whenever conditions warrant, the sheep men and the Baldy Mountain Association received a 10 percent increase.

Both of the above groups have definite plans for future improvements of their allotments.

Vass, A. F. 1926. Range and Ranch Studies in Wyoming. Wyoming Agric. Exp. Sta. Bulletin No. 147, 150 pp., illus.

Wyoming, with almost 62½ million acres of land, the greater part of which receives insufficient rainfall for cultivated farm crops, has long been a great empire for grazing livestock. Three percent of the above area is devoted to the Yellowstone National Park, 3 percent to farm crops, and the remaining 94 percent must be used, if used at all, for timber and grazing. As grazing does not interfere with timber production when properly handled, it means that we have about 59 million acres in the state for grazing purposes. If we allow 40 acres per animal unit as the average carrying capacity, it means that our grazing land alone will carry a million and a half animals such as cows. Our farm cropland, which is largely under irrigation, can supply three months of winter feed and still have sufficient acreage for the cash crops such as grains and root crops. With the above arrangement which is rapidly coming about, the state can support two million animal units. The cropping systems on our farmed lands should always be made to fit in with our livestock production.

The results given in this bulletin are part of a line of work looking toward a careful appraisal of the status and future of the livestock industry in Wyoming. The economic aspects of production and marketing are studied, not as much to show the cost of production, but to aid the rancher in the study and analysis of his business. If such studies bring out the strong and weak points in the operation of the ranches studied, they have served their purpose.

From the earliest history up to the present time one of the greatest resources of this state has been its native forage plants. These plants have supported millions of domestic animals annually. Through the livestock, which have acted as living factories, these plants have supplied us with meat, leather, wool, motive power, and hundreds of other products. In fact, our existence has practically been dependent upon our meadows and ranges. The importance of the grazing land of this state may be realized when we consider that it is conservatively estimated that not less than 59,000,000 acres are annually used for grazing purposes, which is sufficient to graze 1,000,000 head of cattle and 6,000,000 head of sheep the greater part of the year.

The value of such land where the grass could be preserved with very little decomposition was realized as early as 1800 by the Spaniards who had established themselves on the west coast. In 1834, according to Dana in his "Two Years Before the Mast," a single vessel picked up not less than 40,000 steer hides at the California ports, San Diego, Monterey, and Santa Barbara.

The methods of these early stockmen were very simple, consisting of turning the animals loose on the unlimited range, where they could find plenty of forage. There was no danger of overstocking in those days. No effort was made to grow feed for the stock. The rounding up of the animals made up the biggest care.

The industry became more popular and large numbers of cattle were introduced. This, combined with the rush of the gold seekers, pushed the industry farther eastward, over the mountains and into what is now known as Nevada and Arizona. At the same time the settlers were pushing their way westward from the Mississippi River. As they moved into Kansas, they introduced the cattle business into the Great Plains of that state. From here they moved north and westward into Dakota, Minnesota, Wyoming, and Montana, and southwestward into Texas and Colorado. In 1847 the Mormons crossed the so-called Great American Desert and established themselves in Utah. This movement of the settlers introduced the cattle into the parts of this country most important for livestock.

The miners of '49, enroute to the gold fields of California, were among the first to discover the value of our native forage plants. At this time hundreds of wagons drawn by oxen crossed the plains, bound for the new El Dorado. Some of these belated freight trains were caught along the eastern foothills of the Rocky Mountains by the first snows of winter. To continue the journey under such conditions was out of the question, so there was nothing left for the men to do but to construct rude winter quarters and turn their oxen loose to shift for themselves, thinking no doubt that the cattle would either starve or fall a prey to wild beasts. Greatly to their surprise, however, when spring came the oxen were found to be in good condition and ready to resume their journey.

Cattlemen of Texas and elsewhere, when learning that animals could exist throughout the winter season on the native grasses of the Wyoming plains and foothills, drove their herds hither; and it was not long until thousands of cattle were quartered in Wyoming, where grass was plentiful and water abundant. Very soon Wyoming became known as one of the best grass range territories in the United States; and as fast as protection could be given to permanent settlers, the industry grew to large proportions. The industry soon began to appeal to capitalists of the east as an especially renumerative investment. It also made a romantic and adventurous appeal to the nobility and rich men's sons in Europe.

From 1870 to 1886 the cattle industry grew by leaps and bounds. The cattle business became a fad -- a fashion. Rich men's sons, university graduates, college professors, foreign investors in France, England, and Scotland put their money into the business. The fabulous returns of 40 to 50 percent per year were too enticing for even the shrewd Scotchman, and many of the large cattle and land companies were financed in Scotland.

The year of 1882 was the high point in the formation of cattle companies. There were small herds of cattle in the state up to 1870, but it was during the '70's that the cattle business showed the greatest profits. The reports of the enormous profits reached the east and the European countries, and it was during the early '80's that so many of the well-known cattle companies were organized.

The causes of their failure were, first, purchase of their herds by "book count," a common practice in the early boom days. The cattle purchased were not rounded up and counted, but the records on the books were taken as representing the number. The calf crop was figured as a certain percentage; and from the number branded, the number on hand was arrived at. The enormous losses that took place during the severe winters were not taken into account. In many cases the number purchased was double the actual number delivered. It required a few years for their losses to show up. Second, the prices paid for the land and cattle were, in many cases, too high. With the overstocking, severe winter losses, and low prices of 1886 and 1887, many of the companies found themselves bankrupt. Third, the methods used in running the cattle were fitted to the open range when there was plenty of feed; but they were not adapted to the crowded range and years of drouth.

In 1886 the first big loss came. The summer of 1886 was unusually dry, and the cattle were in poor condition before winter set in. In spite of that fact, companies continued to drive them in from the south. The Continental Cattle Company drove in 32,000 head of steers. The Worsham Cattle Company, with no former holdings, turned loose 5,000 head. The Dickey Cattle Company brought in 6,000 head for the Cheyenne and Arapahoe country. Major Smith brought in 5,500 head.

Even with the best of winters the loss would have been heavy, due to the overstocking. As one man expressed it, "It was murder for the Texas cattle." The winter came early and stayed late. It was a combination of recklessness, want of foresight, and the weather. The loss was estimated at 50 percent, but in many cases it was much greater. The Worsham outfit never attempted to gather any of their 5,000 head. John Clay reports that of the 5,500 head of 3-year-olds belonging to Major Smith, they were able to find about 100 head.

The cowmen of the west were broke and many of them never recovered. Among the notables who made their exit at this time were such men as Sturgis, Stuart, Scott, Kobrs, Prince Russell and Roosevelt. To make matters worse, the year of 1887 was a dry one in the corn states; and the demand for feeders was very poor. The work and profits for many years were swallowed up in 1886 and 1887. Failure after failure occurred and those who survived were few in number. Many of the cattle companies were completely wiped out.

A few years later the southwestern states suffered the same fate. The above losses greatly reduced the number of cattle on western ranges. Even to this day the cattle business is materially influenced by the winter weather. Men cannot resist the temptation to try to get something for nothing. That is why the so-called free range appeals to our stockmen today, who make the mistake of overstocking and who fail to provide feed and shelter in case of bad weather. The lessons of these heavy losses are soon forgotten and consequently a bad winter always catches a large number unprepared.

Those who survived the heavy losses of the '80's and who still had faith in the industry were taught the value of saving pastures and raising some hay for winter feed. The competition for the range resulted in much damage to our ranges. Too early grazing and overstocking has had disastrous results.

When the stockmen of the West awoke to the value of the native vegetation for grazing, which was in the early '70's, there was no ceasing in the stocking of the range. They could not breed cattle fast enough, so they trailed them in from the south. It was not long before the best ranges were taken and competition became very keen. The cattlemen's one aim seemed to be to get all the grass they could before someone else appropriated it. No effort was made to raise feed. The range became overstocked and in the winter of 1886 the industry suffered a great setback. Thousands of cattle were not able to stand the winter. The northwest states suffered the most.

The range cattle business originated in Texas and gradually extended northward. Until the Sioux Indians were subdued, Wyoming was not safe for ranching; but with the conclusion of the Indian wars, the cattlemen immediately took possession of the old hunting grounds of the Sioux Indians. Cattle replaced the buffalo and antelope on the plains and foothills of the Rockies. Some of the early ranchers employed as many riders to protect their interests from the Indians as they used for running their livestock.

An interesting and characteristic feature of the early cattle industry was the Old Texas Trail. This was the highway over which a tide of cattle was moved from southwestern and western Texas to the Northern Great Plains and Rocky Mountain states. These states were Kansas, Colorado, Nebraska, Wyoming, Montana, and the Dakotas. The cattle were of the Spanish breed and originated from the cattle taken into Mexico by the Spaniards in the 16th century.

The movement was started in the '60's and reached its high point in 1884, when it was estimated that 800,000 head of cattle moved over the trail. A large number of these cattle came into Wyoming. The first trail herd came into the state in 1871 and consisted of 1,500 head. These cattle were reported to have sold for the following prices: Yearling steers, $7; 2-year-old steers, $12; and cows, $17, an average price of $12 per head.

Texas, with its extensive plains of so-called short grass and with its mild winters, took the lead in the production of cattle and horses. Later, sheep became very popular. The large surplus of stock found its way to the eastern markets by the trails to the northeast. These Texas cattle were of the long-horned, inferior type, and their effect is still noticeable in some of our herds. It has taken many generations of good breeding to develop the type of cattle shown in Figure 1, the type that is now found on many of our ranches.

The Texas cattle were rounded up and trailed up to Kansas, where they met the railroads. The stock were not hurried along the trail but allowed to feed as they traveled, and so they reached the market in fair condition. Many interesting tales are told by the "old-timers" about their experiences on these trails. Thousands of long-horned steers were taken to the market in this way.

The trailing outfits consisted of about 15 men: 12 to handle the cattle, one man to look after the horses, one cook, and the foreman of the outfit. The cook wagon was often drawn by oxen, and carried the provisions, bedding, etc. Each rider kept a night horse saddled and ready to mount.

The cattle were bedded down at night and the men divided into four watches of two men each, who, going in opposite directions, rode around the sleeping cattle. There were, as a rule, some 3,000 in a herd. During good weather there was little danger of the herd stampeding, but during storms there was great danger. When the thunder and rains started, the cattle were restless and likely to stampede. The cattle were trailed for a few hours and then allowed to graze. They were driven about 12 miles per day.

Many of the herds came up what was known as the Old Chisholm Trail, which ran through Throckmorton, Baylor, and Wilbarger counties of Texas, crossed the Red River over into the Indian territory and then up the north fork of the Red River through the Wichita mountains. Dodge City was in the path of most of the herds, and many of them were disposed of there; if not, they were moved on north through Kansas and into Nebraska. Ogallala, Nebraska, was where many of the Texas herds were dispersed. There the northern buyers met the cattlemen from the south. It was not uncommon to be on the trail five or six months. The advantage of this system was that it was easier to raise the young stuff in the south and to finish the 3- and 4-year-olds on the ranges of the north, where the grass was much better, than to raise the calves in the north.

Due to the unsettled condition of the country and lack of control of the cattle, there were always heavy losses due to strays, thieves, and similar causes. In order to protect their interests, the stockmen of the state organized the Wyoming Stock Growers Association in 1872, which was the first organization of this kind ever formed. It represented a capitalization of over $100,000,000, when Wyoming was still a wilderness. The headquarters of the association were in Cheyenne, which was the center of the livestock industry of the state. The association was and always has been a very important factor in the government of the state.

When cattle were first introduced in the state, the land was owned by the government and ranges were free to the cattle owner. Stock in the cattle companies returned good dividends and herds were increased to the highest possible number. This had the effect of overcrowding the

ranges, and a shortage of feed naturally followed. Prices of beef in the eastern cities also declined; managers of the cattle companies found it difficult to keep up the dividends; and the stockholders began to inquire why. Then the expedient was resorted to of shipping every animal available; culls were rounded up and sold as feeders.

In 1889 another factor entered into the conditions. Wyoming was about to be admitted as a state. Many who preferred a state to a territorial government, knowing that Wyoming was likely to be admitted, came flocking into the territory, settling along the valleys where water could be secured for irrigation; and these homesteaders restricted the great cattle ranges. These settlers and the shortage of herbage finally caused some of the large cattle companies to pass a dividend. The stockholder demanded to know the reason and was informed that the reason was due to "rustlers" who were stealing the cattle.

The country up to this time has been any man's land and so the cattlemen took possession. Very few of the great cattle companies took the trouble to file on land under the government homestead laws. A company organized to go into the cattle business would start by first selecting a range. The managers would ride over the country and examine its grazing facilities, water supply, timber and hill protection. They would select the range they wanted and then find the best place on it for the home ranch or headquarters. They then established definite natural boundaries of the range, naming the north, south, east, and west lines. As soon as they got their cattle moved and brands recorded, they would issue a public announcement in the advertising column of the newspaper as follows:

1. A cut of a steer or horse with the company brand thereon.

2. Name of common lists of brands and then a notice as follows:

"Our range extends from the Big Muddy north to the Platte, east to Sheep Buttes and west to Poison Spider." This domain was taken possession of and all parties warned not to trespass.

The early cattlemen all respected these defined ranges, because they were operating under the same rules. The above method held sway during the '70's and '80's without objection or interference. It was a wild, unsettled country that no one cared to use; and the cattle fattened thereon were shipped to market. The cattle business was then one of rounding up, branding, and cutting out the fat cattle that were ready for market. It did not require the amount of capital required today, when large sums must be invested in lands.

The early cattlemen looked upon the so-called settler with disfavor. The settler was required to fence his range in order to protect it and a wire fence was an abomination to the range cattlemen. It prevented the herds from drifting with the storms and finding a natural shelter in the timber and brush on hillsides. Cattle, if left alone, will in most cases take care of themselves. They drift with the storms and later graze back. When they encounter fences they walk back and forth until they are exhausted.

That there were a few settlers scattered throughout the territory who lived by stealing cattle and horses is undisputable. This made the large stockmen look upon the small stockmen and settlers as undesirable. When some of the large cattle companies failed to pay their dividends, due to the reasons already mentioned, they attributed their loss to the rustlers and settlers. This explanation was used until "settlers," "nesters," and "rustlers" became synonymous terms. The story of Cattle Kate and James Averiall, two settlers on the Sweetwater, who were taken from their homes in the night in the summer of 1889 and hanged, illustrates conditions at that time. A man named Waggoner, a settler near Newcastle, was killed by three men. Jones and Tisdale, two settlers in Johnson county, were waylaid and killed in November 1891.

The stealing of cattle became so common that the Territorial Legislature in 1884 passed the maverick bill, which was prepared by the Stock Growers Association. This law made it a felony to brand a maverick, except under the supervision of an authorized agent, and then with the letter "M."

It was reported that in the early days certain unscrupulous cowmen paid their riders an additional wage for branding all calves found without a brand. This was contrary to the law and caused a great deal of trouble. Stockmen complained of the failure to convict men under the maverick law, which increased the bitter feeling between the stockmen and settlers. This led to the Johnson county invasion or what is known as the War on the Rustlers.

A body of men were brought in to terrify the "settlers" or "rustlers," as they were called. The armed troop of 50 to 60 men left Cheyenne for Casper by special train on April 5, 1892. On April 6 the raiders left Casper on horseback for Buffalo, the section where there had been so much trouble. Nick Ray and Nathan Champion were killed at their ranch on Powder River. Near this ranch they met Jack Flagg and his nephew, whom they tried to capture but who escaped, and gave a warning in Buffalo. The raiders were warned that a force of 200 armed men awaited them in Buffalo. They went into camp at the T.A. ranch on Crazy Woman Creek, about 12 miles from Buffalo, where they threw up fortifications. They were attacked by about 400 armed men and would probably have been annihilated had not the acting governor, Barber, wired President Harrison to send the United States troops to the scene. Colonel Van Hain appeared on the scene with three troops of cavalry and took the raiders prisoners. They were taken to Fort McKinney and later to Cheyenne but never brought to trial.

From the standpoint of handling the forage the following steps may be noted:

In the first, or initial stage, the forage was accepted as it was found. No attempt was made to improve it in quality or quantity. The range was absolutely open and the cattle roamed at will, winter and summer, unmolested except for the annual or semi-annual roundups. It did not take long for the range to reach the limit of its stock-holding capacity. Overstocking and short feed led to disastrous years. This was shown in the losses of 1886 and 1887.

The second step was the control and irrigation of certain favorably situated lands. These lands were fenced and used as winter pasture.

It required a number of years to develop the fact that it would pay to put up hay, not so much to carry the stock through the winter, but for securing a limited supply of feed for an emergency.

Step by step the idea of the importance of a supply of feed forced itself upon the stockmen. Thus the fourth period saw most of the land which could be irrigated, fenced, and the feed stacked for winter feeding. Figure 2 shows cattle on such irrigated meadows.

The fifth period is the one where crops other than native hay, such as alfalfa, were grown for winter feed. The large ranches were cut up and we have more of the farm type of livestock raising.

Very little investigation and study has been done on the problems of the range livestock men. The hundreds of publications dealing with livestock production have to do chiefly with livestock in the Middle West, East, and feed lots of the western experiment stations. These results have been of little value to the stockmen, as they, as a rule, are producers of stockers or feeders and do very little feed-lot work.

The climate of the state always has and always will play a very important part in the profits and losses of livestock. Figure 3 shows the enormous death losses that take place during the drouth years. The state is subject to extremes in precipitation. In 1910 the total precipitation was about 10 inches; whereas in 1905 it was over 22 inches. It is not uncommon to have a 50 percent increase or decrease in the precipitation. Such wide variations mean even a greater variation in the amount of available feed for the winter months, and under the system of management practiced in the '80's and the early '90's the losses on many of the herds varied from 2 to 50 percent, depending on the amount of rainfall of the spring and summer months, and on the snow and low temperature conditions during the winter.

The winter of 1879-80 was a very severe one and losses were heavy. No official records on losses are available for those dates, but it was reported at the time to be over 50 percent. Another very severe winter was '86-'87, at which time the very severe losses, previously mentioned, took place. Other severe winters when losses were high occurred in '89-'90, '92-'93, '11-'12, '16-'17, and in '19-'20. In the last 46 years we have had seven periods when losses due to exposure have been very great, ranging from 5 to 10 percent of the total herds. This means that on many of the ranches the losses are very much greater than the figures given because some of the ranchers save a little feed from the good years to carry them through the lean years that they know are sure to come. This means that although the average loss is 10 percent, the loss on some of the ranches reaches a very much higher number. It will be noted in the figure that the years of severe losses follow the years of light rainfall. The heaviest loss takes place the latter part of the winter following the severe drouth.

In most cases the extreme losses occur the year following the drouth. An exception to that is 1910, when the losses took place the same year as the drouth. This was due to the fact that there was such an overstocking up to 1910, that when the dry year came there was not feed enough to carry the livestock through to the first of the following year, which is usually the case. The heavy losses took place before the end of December. The so-called free range has played no small part in these losses. The rancher may know that his range is overstocked should a dry year occur; but during the years when there is abundant grass he must keep it fully stocked, for if he does not someone else will run stock on his range. He must keep it fully stocked during the good years in order to hold it, which means it will be overstocked in the dry years that are sure to follow. Some method of control of the public domain would seem to be desirable in order to correct the above evil.

The soil upon the uplands is dark brown with carbonate accumulation at from one to three feet. The alluvial soil along the rivers and creeks is silt loam and is deeper than the upland soils. The fine texture of the soils makes them especially adapted to the grasses found thereon. The fertility of the soil is sufficient for luxuriant plant growth. The limiting factor in the production of vegetation is moisture. Where water is available for irrigation, excellent crops of winter feed, consisting of alfalfa and grasses, can be grown.

The vegetation of this area is especially well adapted to cattle. The principal grasses are blue grama (Boutelous oligostachya), bluestem (Agrophyron occidentate), needlegrass (Stipa comata), Junegrass (Koeleria cristata), the rush grasses and sandgrasses. The grama grass furnishes excellent summer, fall, and winter grazing upon the uplands. The bluestem furnishes early spring grazing on the bottom lands. The bluestem and the rush grasses are found in the irrigated meadows and are used for hay and winter grazing. Some seeding of the cultivated grasses has been done in the meadows. Reseeding with alsike clover, red top, and the wheat grasses has proven beneficial on some meadows.

The land area per ranch was 7,115 acres. Of this amount 45.6 percent was owned and the remainder leased. Of the leased land, the greater percent of it was privately owned. Thirty-three percent of the owned land and 14 percent of the leased land was tillable. The bottoms and better lands were owned and the poorer lands, which represented in many cases the more recent homesteads, were leased. The grazing land was valued at $7.80 per acre and the crop land at $11.00 per acre. Seventy percent of the leased land was privately owned, and the remainder was school land.

Controlled grazing bears the same relation to forage production that controlled production does to marketing. If the animals are turned out early in the spring before the plants have had a chance to become established, it is detrimental to the plant; and the harm done in early spring will continue through the season. More feed will also be produced if the plants are allowed to make a considerable growth before they are grazed off. It is through the green leaves and stems of the plant that the food from the air and soil are taken into the plant, there manufactured into plant tissue. The less leaves and stems a plant has, the less its ability to manufacture more plant tissue. The plants should be allowed to obtain a good start, and occasionally they should be allowed to reseed. By meadow improvement and controlled grazing the carrying capacity of our ranches can be increased and at a profit to the operator.

Waldron, Charles B. 1960. Range Improvement of the Flagtail Allotment Through Grazing Management. Abstracts of papers presented at the 13th Annual Meeting, ASRM, pp. 47-48.

Early day use of the Flagtail Cattle Allotment on the Malheur National Forest in eastern Oregon was similar to what probably occurred on most public land areas of the West. Use began as soon as the snow melted and grass started growth. Cattle remained on the range until the forage was completely utilized or until winter storms forced cattle to lower areas. Early records on the Malheur Forest show a grazing season beginning April 15 and ending on October 31st.

In a report dated October 28, 1918, a grazing examiner from the District Office, now the Regional Office, made the following observations and recommendations: "Due to frequent impassable nature of the roads during the early part of the year, the salt should be delivered on the ranges in the fall or winter, so as to have it available at the beginning of the grazing season.

"The forage had evidently been closely grazed during the 1918 season, since at the time of the inspection most of the cattle had left the range. The range at that time had started a luxuriant growth of grasses, and there was a tendency for the cattle to drift back on the forest range. The season was evidently not a usual one. However, it seemed to indicate that there was an excessive use during the forepart of the season, since there was practically no old grass remaining at the time of the inspection."

In view of the fact that early records indicate excessive grazing use on the Flagtail, it is not surprising to the present day range manager that a severely depleted range developed. W. L. Dutton, Supervisor of the Malheur National Forest and later Chief of Range Management for the Forest Service, prepared a report in September 1932 that included photographs of a typical meadow type found on the allotment. The photographs showed an area almost wholly devoid of vegetation, loose pulverized soil, and a stream channel four feet deep and six to ten feet wide. This was the Flagtail in 1932.

Construction of boundary fences was started in 1933 and was completed by 1939. In 1934 the opening of the grazing season was changed from May 15 to June 1st. The Flagtail Allotment ranging in elevation from 5,000 to 6,650 feet is less than one degree from the 45th parallel. June 1st is the normal opening date for most allotments at similar elevations in the Malheur area.

In addition to the completion of the allotment boundary fence in 1939, the first division fence on the Malheur Forest was constructed on the Flagtail Allotment in that year, thereby providing for a system of rotation grazing. This system of grazing was initiated in 1940.

In 1939 four camera point studies were established on the Flagtail Allotment. A study of the 1939 pictures shows a change from the denuded area of 1932 to a predominately weed-type range with only an occasional grass plant in evidence. Streambanks had no vegetation and bank cutting and channeling were still unchecked. The simple system of rotation grazing of turning out on alternate units each succeeding year with a move to the second unit by mid-season continued through the 1940's. In 1950 an additional 5,000 acres were added to the allotment. This area was to be used as an early unit. In addition to the 5,000 acre unit, two additional units, one 2,200 acres and the second 1,200 acres in size, were created from the two large units and were to be used as early units in order that turn out on the large units of the allotment would be delayed until approximately July 1st. In 1957 a fourth early unit of approximately 2,800 acres was created by the construction of 1-3/4 miles of fence. At the present time the Flagtail Allotment is made up of six units, four of which may be used as early units. It is now possible to have a complete deferred rotation system of grazing on the Flagtail. Two spring units can be completely rested each year.

The camera point studies that were installed in 1939 were rephotographed in 1956. A marked change had taken place in the 17-year interval. The meadow, that in 1939 was made up entirely of a weed-type forage, was now nearly a solid sod of Kentucky bluegrass. Only occasional perennial weeds are in evidence in the 1956 photograph. The grazing season of June 1st to October 15 was still in effect. Permitted numbers of cattle on the Flagtail Allotment in 1939 was for 700 head. In 1946, due to a transfer of preference, the obligation was reduced to 593 head, which is the present stocking. The rotation system of use initiated in 1940 has continued through to the present time. The only changes in management since 1940 has been the reduction of 107 head of obligation and the creation of the spring units as previously described.

In 1950, 15 Parker condition and trend clusters were installed on the allotment. Five clusters each were placed in meadow, timber, and sagebrush types. These Parker transects were reread for the first time in 1958. A summary of transect data and a study of the photographs taken in connection with the transect installation show that the meadow types have continued improvement or at least are in the same condition as in 1950.

Permittee reaction to the system of use is encouraging. The principal permittee on the Flagtail has stated that in spite of the additional moving of cattle, the additional fencing and water necessary to carry on a rotation deferred system of grazing, there is no doubt that it is paying off. It is paying both in pounds of beef produced and in range improvement.

Wilcox, E. V. 1911. The Grazing Industry. Hawaii Agr. Exp. Sta. (Unnumbered) Separate, 91 pp.

Historical Sketch of the Public Domain

The public domain, exclusive of our insular possessions, originally embraced all of the United States west of Georgia, North Carolina, Kentucky, West Virginia, and Pennsylvania. The area of this tract was 1,855,780,427 acres. The title of the Government of the United States to this land was acquired through cession by states, purchase, treaty, conquest, and settlement.

The greater portion of the territory east of the Mississippi and outside of the Thirteen Original States was claimed by these states on the basis of grants from Great Britain. The states thus concerned ceded this land to the general Government at various dates between 1781 and 1802. The total area of state cessions was 259,171,787 acres.

On April 30, 1803, the Louisiana Purchase was made by treaty with France. This territory embraced the present states of Louisiana, Arkansas, Missouri, Iowa, Nebraska, North and South Dakota, Indian Territory, and parts of Kansas, Minnesota, Montana, Wyoming and Colorado. The area thus added to the public domain amounted to 565,166,080 acres and cost $15,000,000.

By treaty with Spain, February 22, 1819, Florida was purchased for $5,000,000. This purchase increased the public domain by 44,639,360 acres.

On June 15, 1846, the Oregon boundary question was finally settled by treaty with England. The "Oregon country" embraced all of Washington, Oregon, and Idaho, and those parts of Montana and Wyoming which lie west of the Continental Divide. The total area of this region was 191,795,200 acres. This country was not included in the Louisiana Purchase. Our claims to it as enumerated by Ross of the Oregon Boundary Commission of 1824 were as follows: Discovery by Gray in 1792, exploration by Lewis and Clark in 1805, Astoria settlement in 1811, and Florida treaty of 1819. By this treaty Spain gave up all claim which she may have held regarding the northwest coast. Oregon was actually prevented from falling into the hands of the English and was saved for the United States by American settlers, aided and encouraged by Marcus Whitman, Fremont, Senator Benton, Hall J. Kelley, Wyeth, and others.

A treaty with Mexico February 2, 1848, secured to the United States California, Nevada, Utah, and parts of Colorado, Arizona, and New Mexico. This territory embraced 334,443,520 acres and cost $15,000,000. By the Gadsden Purchase December 30, 1853, the Mesilla Valley in Arizona and New Mexico was added to the public domain. This tract of 29,142,400 acres cost $10,000,000.

The State of Texas, when admitted into the Union, retained control of its lands. The national domain was thus greatly increased without any addition to the public domain. The United States, however, on September 9, 1850, purchased from Texas 61,892,480 acres at a cost of $16,000,000. This area embraced parts of Kansas, Colorado, New Mexico, and the "public land strip." Alaska with an area of 369,529,600 acres was purchased from Russia March 30, 1869, for $7,200,000. For various reasons, however, Alaska is omitted from the present discussion of the public lands. On account of the reservations of North Carolina with regard to land claims in Tennessee, the general Government relinquished all claim to public land in the latter state. The actual public domain with which we have to deal in the present discussion embraced therefore about 1,455,000,000 acres.

Congress has absolute control of the public lands and may pass any needful regulations regarding their protection and utilization until they are disposed of. Although the governmental ownership of the public lands was complete, the idea of making these lands comparable with the crown lands of Great Britain was apparently never entertained. As soon as title was obtained, Congress began to dispose of the public lands to private individuals and corporations.

The first plan for the disposal of the public lands was proposed by Alexander Hamilton, Secretary of the Treasury, in 1790. His report to the House of Representatives contained the following suggestions:

"That in the formation of a plan for the disposition of the vacant lands of the United States there appear to be two leading objects of consideration; one, the facility of advantageous sales, according to the probable course of purchase; the other, the accommodation of individuals now inhabiting the western country or who may hereafter emigrate thither. The former, as an operation of finance, claims primary attention; the latter is important as it relates to the satisfaction of the inhabitants of the western country...Purchasers may be contemplated in three classes: moneyed individuals and companies who will buy to sell again, associations of persons who intend to make settlements themselves, single persons or families...

"A plan for the sale of the western lands, while it may have due regard for the last, should be calculated to obtain all the advantages which may be derived from the two first classes."

Hamilton accordingly recommended that the lands be sold in any quantities without limit and that convenient tracts be set aside for location by settlers in quantities not to exceed 100 acres to each person. Hamilton thus clearly foresaw the three chief sources from which have come demands for the public lands viz.: land speculators, settlement colonies, and homesteaders.

During the first years of its existence, the Government of the United States needed money; and the public lands were naturally looked to as an important source of revenue. In 1795 a law was passed turning the proceeds from the sales of public lands into a sinking fund for the redemption of the public debt. In 1796 Congress provided for the sale

of lands in Ohio in sections and quarter townships at $2 per acre. In 1800 a unit of 320 acres east of the Muskingum and 640 acres west of that river was established, together with the system of disposition through registers. The same act provided for the leasing of the public domain in sections or half sections for a term not exceeding seven years. Certain lands were offered for sale in tracts of 160 acres. In 1820 Congress provided for the sale of 80-acre lots of land at a minimum price of $1.25 per acre, with a "double minimum" of $2.50. The various prices at which land was sold between 1785 and 1880 were 12½, 25, 50, 66-2/3, and 75 cents and $1.00, $1.25, and $2.50 per acre.

Between 1801 and 1841, 16 preemption acts were passed. The fundamental idea contained in these acts was to give settlers preference over land speculators. This system in its final form gave settlers the right to occupy public land in areas of not more than 160 nor less than 40 acres, for a certain period at the end of which they were required to pay $1.25 per acre for the land. While according to the Preemption Act a premium was set upon actual settlement, yet title to the land could not be acquired except by purchase. The Preemption Act is thus clearly distinguished from the Homestead Act, according to which final title to the land can be obtained merely from a residence of five years. The idea of holding the public lands for revenue thus gave place to that of devoting them to the encouragement of settlement. The agitation for free homes for settlers, however, did not assume a definite shape until the formulation of the platform of the Free Soil Democracy in 1852, the 12th plank of which read as follows: "That the public lands of the United States belong to the people, and should not be sold to individuals nor granted to corporations, but should be held as a sacred trust for the benefit of the people and should be granted in limited quantities, free of cost, to landless settlers."

This proposition was kept constantly before the public until, in 1862, the Homestead law was enacted. The idea of free homes was thus realized. The Homestead law made possible the acquisition of complete title to 160 acres of land by a residence of five years upon the selected location. A commutation clause was subsequently added according to which the settler, at the end of six-months' residence on his claim, could at once secure title by the payment of $1.25 per acre.

The Timber Culture Act, passed in 1873 and amended in 1874, enabled settlers to acquire title to 160 acres of land on condition of growing a certain amount of timber. In 1875 an act was passed permitting the sale of desert lands in California in areas of 640 acres at the rate of $1.25 per acre. The "Desert Land Act" was passed in 1877 and made to apply to the Dakotas, Montana, Idaho, Washington, Oregon, California, Wyoming, Utah, Nevada, Arizona, and New Mexico. The unit of sale was 640 acres and the settler was allowed three years in which to get water on the land. Under this act the land cost $1.25 per acre but residence was not necessary.

By utilizing the Preemption, Homestead, Timber Culture, and Desert Land Acts, it was possible for one person to secure title to 1,120 acres of land; but the Desert Land unit was later reduced to 320 acres; and in 1891 the Preemption and Timber Culture acts were repealed.

In addition to the agricultural acts mentioned above, various other methods of disposal have been adopted from time to time. In this way immense areas of the public lands have passed out of the control of the Federal Government. From a total of about 1,455,060,000 acres of actual public domain, more than 155,000,000 were granted to railroads to assist in construction; 66,076,550 acres were given as bounties for military and naval service; and 190,000,000 acres were donated to the states for the support of schools, land grant colleges and other purposes. The total amount of public domain disposed of from its origin to 1883 was about 620,000,000 acres; and since that date, the disposal was ranged between 8,000,000 and 27,000,000 acres per annum. The present area of the unappropriated public domain in the public land states and territories is about 400,000,000 acres, lying almost entirely west of the Mississippi and Missouri and in the arid or semi-arid region. The following discussion deals with the characteristics and utilization of this remaining area of public lands.

Buffalo. At the present time the most important cause of deterioration in the range is overgrazing, and doubts have been expressed by many agricultural writers and stockmen as to the possibility of the range recovering from effects of overgrazing. It is interesting in this connection to examine briefly the effects of the grazing of the innumerable herds of buffalo, which predominated over all other animals upon the range at the time of the earliest settlement of the western country. That these animals must have been an important factor in this problem is apparent from a mere consideration of their immense numbers. C. J. Jones gives the following statistics, on the basis of his estimates, of the number of buffalo on the range in 1865, 15,000,000; in 1871, 12,400,000; and in 1875, 1,000,000. The number of these animals in the days of their greatest abundance was therefore considerably in excess of the present number of cattle which occupy the same range. Since it may be assumed that the buffalo require as much for sustenance as domesticated cattle, it is but natural to suppose that large quantities of grass would be eaten by them. While the buffalo ate nearly all kinds of grass and some shrubbery, it seemed to prefer the buffalograss over the greater part of its natural range. In speaking of this grass, Bell states that "Its close, thickly matted fibers keep the ground very dry by preventing the rain from penetrating into it. I have noticed time and again after a sudden thunder shower how rapidly the rain flowed off into the gullies, filling up the streams and helping to cause those sudden floods which so often harassed us on our march. Doubtless no grass could bear so well the heavy tramp of thousands of buffalo...but... as settlers advance, deeper rooted grasses take its place...opening up the soil and retaining the moisture in the ground."

Gilpin estimates that the number of buffalo, wild horses, and elk together amounted to not less than 100,000,000 in the year 1873. With regard to the number of buffalo which actually traveled in one continuous herd, there are hundreds of statements in the reports of travels; and these statements naturally vary according to the time of year and the tract of country covered by the traveler. The number of buffalo in moderately large herds is usually estimated at from 10,000 to 100,000. Greely, however, gives the following account of an immense herd which he observed. "I know a million is a great number, but I am confident that we saw that number yesterday. Certainly all we saw could not have stood on ten square miles of ground...The soil is rich and well matted with their favorite grass, yet it is all (except a very little on the creek bottoms near to timber) eaten down like an overtaxed sheep pasture in a dry August."

Perhaps the largest estimate which has ever been made of a single continuous herd of buffalo related to a herd seen by R. I. Dodge in 1871. The data and figures given by Dodge were examined by Hornaday. After making allowance for all factors which could be concerned in the case, Hornaday makes large reductions from the possible figures "which would leave 4,000,000 as our estimate of the actual number of buffaloes in this great herd, which I believe is more likely to be below the truth than above it."

When Lewis and Clark reached the Great Falls of the Missouri in 1805, they found that the soil was very much cut up by buffalo. "The grass, which is naturally short at this time, is still more so from the recent passage of the buffalo." Long, when speaking of the country at the forks of the Platte, says that there was a "verdant plain" upon which thousands of buffalo were grazing. On the south side of the South Platte "The Plains are more closely depastured, the grass is fine and short." J. A. Allen, referring to the annual northern and southern movements of these animals, says, "The route which these animals follow in their migrations occupies a width of several miles and becomes so marked that, besides the verdure destroyed, one would believe that the fields had been covered with manure." Parker says that where buffalo had recently grazed it was exceedingly difficult to find enough grass for the horses. Raynolds speaks of the destruction of grass by buffalo on Powder River. "At a few low points we found a coarse grass that the buffaloes had rejected, but our mules ate it with avidity." At another point "The grass on the river surpassed our expectations in quality, thus indicating that the buffalo had been in the valley but a short time."

The accounts indicate what would naturally be expected, viz., that where buffalo congregated in immense herds, the grass was totally destroyed for the time and the ground was much cut up or packed down, according as dry or wet weather prevailed. The result of such accumulations of large herds, however, was the apparent total destruction of the grass. Even in the days of the great cattle kings of the west, the herds of cattle were comparatively small, numbering only a few thousands. It is therefore apparent that injury to the range on account of overcrowding and overgrazing from cattle was then and is now a quite unimportant

factor in the destruction of the range as compared with the enormous herds of buffalo. It should be remembered, however, that despite the fact of apparent total destruction wrought by the buffalo along the line of their migrations and during their close association at breeding seasons, the range recovered so that the evidence of their destructive grazing was entirely lost within a few years. This fact indicates also the possibility of range improvement at present. The buffalo, after passing through a range and destroying the grass, did not return by that route or visit the range again until the grass had recovered from the effects of overgrazing; and since climatic and soil conditions on western ranges have not changed to an appreciable degree since the earliest historical times, it may be reasonably assumed that even ranges which have been most abused by overgrazing have excellent prospects of recovering their former productiveness if allowed a seasonable resting period.

No attempt has thus far been made in this discussion to define what is meant by overgrazing. The most satisfactory meaning to ascribe to this term is that of an extent of grazing which, when persisted in for long periods, will gradually lead to the deterioration of the range conditions. A moderate amount of grazing may be taken as meaning an amount of grazing which can be persisted in indefinitely upon a given range without causing any such deterioration in the grass. The effects of moderate grazing upon ranges or in forest reserves is apparently no more injurious than the removal of a crop of grass annually by means of a mowing machine. The question of whether the range grasses are being exterminated or being displaced by less desirable species and weeds can only be determined after careful observations extending over a period of years.

J. G. Smith calls attention to the fact that in Texas some stockmen seem to believe that the country was never grazed until sheep and cattle were introduced; it was therefore difficult to persuade them that the observed results of overgrazing in certain localities were not a new phenomenon but that similar conditions had prevailed from time to time as a result of the grazing of buffalo and wild horses. "The intermittent grazing and resting of the land resulting from the roving habits of the buffalo and mustangs was an ideal method ot pasturing and improving the natural pasturage." Attention is also called by this author to the fact that after the destruction of the buffalo, a short period intervened during which the cattle and sheep business was being developed and during which the number of domestic animals was quite insufficient to eat as much grass as had previously been consumed by buffalo. The native grasses therefore attained a height and thickness of growth which was considerably greater than the average, until they were grazed off during the days of the cattle kings in the '80's.

Williams, Ralph M., and A. H. Post. 1945. Dry Land Pasture Experiments. Montana State College, Agricultural Experiment Station, Bulletin 431, 31 pages, illustrated.

The Central Montana Branch Station, which is 4,300 feet above sea level, is located about two miles west of Moccasin, Montana, in Judith Basin county. The Judith Basin area comprises approximately two million acres of tillable land, a large portion of which has been farmed. The Basin is almost wholly surrounded by mountains and is drained by the Judith River. The greater part of this area consists of gently rolling or nearly level benchlands.

The climatic conditions prevailing at the Central Montana Branch Station, which is located approximately in the center of the State, are fairly representative of a large portion of the dry land area of Montana.

In the interpretation of the experimental results to be presented later, it should be kept in mind that the four years 1934, 1935, 1936, and 1937 were extremely low in both annual and seasonal precipitation, resulting in one of the most extended droughts recorded in the area. Associated with the lack of precipitation were high wind velocity and evaporation. In contrast, the two years 1941 and 1942 were the opposite extreme, having the highest annual and seasonal rainfall recorded during the 10-year period 1934-1943.

In the spring of 1940 a reserve crested wheatgrass pasture of 23.6 acres, which was seeded at the same time and at the same rate per acre as the pasture previously discussed, was divided into two parts of approximately 12.3 acres each. The purpose of this grazing trial was to determine the value of a rotation system of grazing in contrast to the regular grazing procedure. Previous to 1940 this field, which joins the other crested wheatgrass pasture on the east, was utilized as an auxiliary pasture or cut for hay. Since these two pastures were seeded at the same time and have comparable vegetative cover or stands of grass, the grazing results for the 4-year period 1940-1943 may be compared.

These two crested wheatgrass pastures for the four years (1940-1943) were comparable. The stocking rate and general experimental procedures were the same for the two pastures, with the exception that the animals on the rotation pasture were rotated from one 12.3 acre unit to the other every two or three weeks depending on the utilization of the grass. Although there was some variation in results for individual years, the average data for the four years are quite similar. The 4-year average daily gain per animal was exactly the same for the two systems of grazing. There was a slightly longer average grazing season and 6 percent greater total gain in animal weight per pasture and per acre for the rotation system. On the basis of these results, it is doubtful that the rotation system of management for crested wheatgrass would justify the extra time and expense involved. However, the rotation system may be justified where limited pasture is available or where this system of grazing may help in the control of animal diseases.

Wilson, M. L., R. H. Wilcox, and G. S. Klemmedson and V. V. Parr. 1928. A Study of Ranch Organization and Methods of Range-Cattle Production in the Northern Great Plains Region. USDA Tech. Bull. 45, 92 pp.

Beef-cattle production has long been the most important business enterprise in the northern Great Plains region; but for more than a decade, the industry has been undergoing deep-seated changes. In 1927 it is still in a more or less disorganized condition. The northern Great Plains include the contiguous parts of North Dakota, South Dakota, Wyoming, and Montana.

There have been many causes for the changes which have taken place and for the unsettled condition of the present. Some of these causes are the results of such fundamental influences as the passing of the open ranges, which were formerly a part of the public domain, into small individually owned units through the various forms of homesteading, and the consequent development of dry-land farming.

The typical dry-farming lands in this region in many cases have been cropped for a period of 20 years. The experience of farmers, together with the crop-production data of the experiment stations, gives a definite basis for evaluating the production of farming lands; but a large portion of the northern Great Plains is rough, untillable land that can be used only for grazing. The prosperity of these communities to no small degree will depend upon the intelligent use of this range resource.

Changed economic conditions in the cattle industry as it came out of the depression period following the World War demand that many adjustments be made in ranch organization. These same economic forces, still at work, make necessary the careful selection of methods and practices in producing cattle to get the greatest income. There is probably no better way of determining what are successful business methods and management practices than the study of the results obtained on a large number of ranches. It was for the purpose of getting a record of the organization and operation of a large group of ranches that the United States Department of Agriculture in cooperation with the agricultural colleges and experiment stations of Montana, Wyoming, North Dakota, and South Dakota made a study of 304 ranches in the northern Great Plains region.

The northern Great Plains region, as considered in this bulletin, embraces that portion of Montana that is east of the Rocky Mountains, the northeastern quarter of Wyoming, and thoseportions of the Dakotas that lie west of the 100th meridian, except for a small area in the north-central part of North Dakota. (Fig. 1) The region comprises approximately 152,000,000 acres of land, of which 17,000,000 are devoted to crops, including wild and tame hay, ceral, and forage crops.

Drainage of the region is accomplished by the Missouri River, which projects its tributaries into the various areas to form a network of smaller streams. Very generally, even a small stream has an influence on ranching in the comparatively small area through which it passes because of the possibilities of a water supply, because of moist or irrigated land for wild hay or crop production, and because of the usual adjacent rough, broken ranges that furnish winter protection to livestock.

Aside from winter protection, topography seems to have an indirect influence on ranching in this region, except possibly in the Black Hills locality. The direct influence of topography is on the production of certain crops which in turn may influence ranching. But there is some relation between topography and soils, both as to types of soil and area of desirable type soil for crop production. In the "Bad Lands" district the proportion of level land to rough land is small. It is necessary to utilize every available acre of the level land for winter-feed production in order to be able to utilize the rough land for spring, summer, and fall grazing.

The precipitation of the northern Great Plains region varies from about 20 inches in the eastern to about 13 inches in the western portion of the region. The whole is a region of summer rainfall, as approximately 75 percent of the annual precipitation is received between April 1 and September 30. Wide variations often occur in the amount of rainfall from year to year and in its distribution within a single year. Extremely wet or extremely dry years may occur singly or consecutively. The normal amount of rainfall may be received during a certain year, but its distribution may be in the form of light showers of limited value to crops and summer grazing because of high surface evaporation. Torrential downpours over small localities or over relatively large districts are not uncommon. The precipitation received between October 1 and the last of March amounts to the approximate equivalent of about 4 inches of rainfall per annum. A considerable amount of this, however, is usually in the form of snow and may have an important influence on the use of range for winter grazing.

Among the important factors that influence the benefits derived from rainfall are temperature and wind velocity. The climatological data of the region indicate that it is one of extreme temperatures. During the winter a temperature of -30° to -40° F. may prevail for several consecutive days. During the comparatively short summers, temperatures as high as 100° F. may prevail for several days in succession. The mean winter and summer temperatures are considerably above and below the respective temperatures mentioned.

High wind velocity during the winter tends to blow the snow into drifts which leaves some areas open for a limited amount of grazing. High wind velocity during the summer tends to increase surface evaporation and in extreme cases is very detrimental to the growth of field crops and range grasses, particularly if accompanied by high temperature.

Climate has a most important influence on the ranching industry in this and other western regions. Weather records showing the extreme variation and the average condition with regard to annual and seasonal precipitation, temperature, evaporation, wind velocity, and length of growing season should be of special interest to livestock producers in any locality or region. The variations, especially in subnormal rainfall and abnormal snowfall, that may prevail within a year or a succession of years are factors that must be considered seriously in formulating plans of ranch operation in any region of the Western States. Extremely dry grazing seasons followed by more or less severe winters usually result in situations difficult to overcome without financial loss or incurrence of high operating expense.

"Medium" to "good" range conditions prevailed in 29 out of the 43 years of record. In only 4 of the 43 years were the conditions above "medium" to "good," whereas for 10 of the 43 years a condition below "medium" to "good" was recorded. It may be noted in some instances that "poor" range conditions in the early season improved to "good" during the summer season. The early condition, therefore, is not a positive indication of what the summer condition will be. The condition of the range during the summer is of special importance in this region because of the influence on the condition of cattle marketed during the following fall. In addition, summer rains largely determine the quantity of native grass available for fall and winter grazing. A low yield of hay may be overcome in part by excellent range conditions during the fall, followed by a mild winter. But to depend upon such a favorable sequence of seasons is a risk too great to take without preparation for an emergency. The interdependence of seasonal conditions as affecting the ranching business very often puts ranchmen in difficult situations even though a conservative production policy is followed.

The most important range grasses of the northern Great Plains region are grama, buffalograss, and the wheatgrasses. Many combinations of these with grasses of lesser importance occur to form range types. The various types are usually confined to certain types of soil, and the predominance of any particular grass is usually determined by the quality of the soil and the usual rainfall conditions. Certain range types are worthy of special mention because of their predominance in the region and their value for grazing.

Previous to 1870, agriculture as an established industry was negligible in this region; but the Territories of Montana and Wyoming, established, respectively, in 1864 and 1868 from Dakota Territory, soon became attractive to cattlemen, sheepmen, and farmers on account of the grazing resources and the available farming lands. Farming did not gain a very strong foothold until the building of railroads opened means of transportation for farm products. The agricultural development of the region since 1870 may be roughly divided into several periods, each marked by the fact that a certain type of agriculture came into prominence.

During the period from 1870 to 1880 the cattle business experienced wide expansion and little competition from farming. In 1871 the first trail herd of cattle came into Wyoming from Texas. In 1876 a band of sheep came into Montana from California. These movements are significant of the wide territory from which the region drew its livestock, especially during the years of greatest livestock expansion. During this period millions of acres of former Indian reservations were withdrawn as such and were added to the existing large area of public domain. Reliable statistical data are not available regarding numbers of livestock in the region during that time, but the records of Montana show 274,000 cattle and 250,000 sheep in 1880. As the record shows only 87,000 cattle in Montana in 1873, a rapid increase in numbers is indicated in spite of the existing conditions. The record further shows approximately 170,000 sheep in 1879, which indicates a very rapid increase, especially for one year. Concurrent with these conditions in Montana, the Black Hills locality was attracting attention because of the discovery of gold in 1874. This brought prospectors, many of whom turned farmers and cattlemen at later dates.

Soon after 1870 a condition existed in the southern range regions that influenced, more or less, the movement of cattle into Wyoming and the Dakotas. The principal outlet for Texas cattle was through the shipping points in western Kansas and Nebraska. Those points were the meeting places of eastern cattle buyers and range men. Because of the great numbers of cattle arriving at the shipping points, the system of holding cattle on neighboring ranges for further grazing was developed. As conditions became crowded about the shipping points and as market prices fluctuated, the holding grounds were expanded, and uncrowded ranges were sought. Wyoming was one of the first states to receive the overflow.

In the early eighties a veritable flood of cattle went into the region, especially from the southern ranges. In 1880 the Utah Northern Railroad came into western Montana from Ogden, Utah. In 1882 and 1883 the Northern Pacific Railroad came into North Dakota and Montana, and in 1887 the Great Northern Railroad reached Montana. Improved transportation facilities gave an added impetus to the expansion of the livestock industry, until the ranges became heavily stocked, as compared with former years.

During this period there was considerable activity in the homesteading and purchase of the most valuable lands to be used in connection with the vast area of public domain. The principal demand was for the irrigable and other good hay land. As cattle became more numberous and the ranges were more heavily grazed, winter feeding became necessary.

Another factor that stimulated feed production and land acquirement should be considered. In the early movements of cattle from the southern ranges, the herds consisted almost entirely of steers which were grazed two or more summers and were sold when 4 to 6 years of age. As the trade increased and the demand for steers became keener, great numbers of cows were moved into the region with the expectation of carrying breeding herds on the northern ranges to produce steers. As cows could

not raise calves and withstand the winters, it became necessary to raise feed for them. The steers could "winter" themselves, especially when well-protected range could be found with a fair amount of grazing during normal years.

Homestead entries of all classes increased during the period 1880-1890. Cattlemen increased their hay land by purchase of additional acreage. Ownership of hay land with a small acreage of range land was considered a safe basis for operation because of the immense acreage of public domain. Practically the only hindrances to use of the public domain were range rights of other cattlemen and the entrance of sheepmen. Under the ordinary system of use, contentions often arose between the two classes of producers over the use of range.

The years 1886 and 1887 were the most trying that had confronted the cattlemen of the region. The ranges were heavily stocked, and grazing conditions were far below normal during the season of 1886. The hay crop was short, and the following winter was very severe. Cattle died by the thousands. Financial losses were heavy and many men were forced to leave the business. Others made vigorous attempts to find their money where they had lost it and many regained a footing in the cattle business.

Movements of cattle into the region continued into the nineties. After the latter eighties the trail movements all the way from the extreme southern ranges were more or less discontinued; and Orin Junction, Wyoming, became a railroad unloading and distribution point. As it was situated near the center of the eastern half of Wyoming, the trails to Montana and to what is now North Dakota were merely prolongations of those leading to northern Wyoming and to the present South Dakota ranges from that point.

During the period 1890-1910 cattlemen did not depend entirely upon the open range; but each maintained a headquarters of owned land consisting principally of hay land, using the public domain as prescribed by water rights and other unwritten laws of the range. Certain localities, because of the grass produced and winter protection afforded, were reserved by consent of the users for wintering purposes. Usually the first cattle work in the spring was to work out the winter range and drift all cattle to the summer ranges to permit growth of grass for the next winter season. During the fall working, cattle were drifted toward the winter range. Large operators necessarily employed comparatively large numbers of men, a common ratio being one, regularly employed to each 1,000 head of cattle. Saddle horses and roundup wagons were maintained in necessary numbers. Operations were systematized as applied to both the individual outfit and to areas of range. In working a range of a certain district or locality, representatives of adjacent operators made up the roundup crew, each man looking after the interests of his employer. In return representatives were sent to other roundups, and in each case the work was handled systematically.

Sheep production increased materially in the western portion of the region, especially after 1880. In 1892 sheep suffered a marked decline in prices. Many sheepmen sold out and did not return to the business even when it regained a better market condition. The low market price was a serious blow to the sheep business, and the limited expansion that followed the more favorable market did not nearly make up for the reduction of numbers following the depression. Some districts experienced an almost entire passing of sheep, which were replaced by cattle. Contentions between sheepmen and cattlemen during this period resulted in the enactment of certain herd laws applying within the respective states. To this date some of those laws have not been revised to meet the changed conditions.

On the whole, the period from 1890 to 1910 was one generally favorable to cattle production. There were some lean years, when range conditions and hay yields were very unfavorable; 1897, 1900, and 1903 may be mentioned especially. The worst economic features were the panic of 1907 and market fluctuations. From the best information available it seems that operating expenses increased during this 20-year period. Operators could stand slight increases in operating expenses because most of the grazing could be had for the cost of labor to handle the cattle. Interest rates were comparatively high. The investment was principally in cattle that were increasing in numbers and weight and could be disposed of as the market price invited or as interest payments and range conditions demanded.

The period from 1910 to 1920 exceeded all previous 10-year periods several times over in the movement of homesteaders into the region, as indicated by various records. This movement was due to the passage of the 320-acre homestead law in 1909 and the 640-acre law in 1916. The amount of extremely good farming land was not sufficient to supply the demand, and inferior lands were also taken. The movement assumed vast proportions and dealt a telling blow to range men because the supply of open range really became limited and the position of the cattlemen became cramped, especially those who were depending to a very great extent upon the public domain for grazing. From 1910 to 1916 crop yields were fairly good. Some of the homesteaders on receiving patent sold their land, but the out movement was not general.

The declaration of war in Europe had a stimulating effect on cattle and grain production. It was expected that foreign trade would be developed. Market prices became stronger. Additional stimulation was given to homesteading in 1917 upon declaration of war by the United States. Young men going into the military service were by law permitted to file on homesteads and numbers of them took advantage of the opportunity. A considerable proportion of certain localities were filed on by men in the military service.

This influx of settlers interested the users of the range. Opinions varied as to whether the settlers would be able to stay, because of the hazards of farming. Favored with only a few lean years as compared with the number of years of good crop yields from 1890 to 1910 many of

them stayed. Some failed or became dissatisfied, sold their land if patent had been granted, and left the country. Some range men took advantage of the opportunity to acquire land and bought it at low prices. Others preferred to use the abandoned land, which was limited in extent but which was free of charge. Some of the homesteaders made good crops and enlarged their holdings by buying out other farmers. By 1910 many cattlemen were in a more or less crowded condition, especially in those localities of level land which offered farming possibilities and a water supply.

The cattlemen in the rougher range areas were not as badly disturbed, except for possible homesteading of summer range, which was rather plentiful even at this time.

Concurrent with the above activities of cattlemen and sheepmen of the region, there was an in movement of farmers, or home seekers. Practically everyone who came in went into some cattleman's or sheepman's range -- his range according to the laws of the range but not according to the statute -- and took a homestead. During the early years of homesteading there was an abundance of good land accessible to water. Those locations were the first chosen. With the closing of each watering place, cattle and sheep had to be shifted to other ranges where water was available. From 1890 to 1910 the numbers of farms increased approximately 150 percent. More irrigable land had been available in Montana than in other parts of the region, but by 1900 all of this had been taken up. From 1900 to 1910 the settlers went to the dry land.

From the spring of 1917 to the spring of 1919 conditions in the southwestern range area were not favorable. A severe drought prevailed. Comparatively large numbers of the southern cattle were moved to the ranges of the northern Great Plains region, and at the close of 1918 the latter were stocked heavily. The year 1919 was a very poor one. The early spring range was medium, and the summer range and hay crop were failures. The cattle were not fat in the fall, which limited the possibilities of sale at favorable prices. Feed was scarce and extremely high in price. Cattle were high.

Several plans were open to consideration: (1) Sell the cattle for what they would bring, (2) ship to other ranges, (3) attempt to winter them on the range, or (4) buy feed for wintering. Comparatively few cattlemen shipped to market. Some of the larger operators shipped to other ranges. The acute car shortage prevented shipment to market or other ranges by numbers of operators who considered the movement otherwise advisable. As a matter of choice in some instances and as a necessity in others, many held and wintered their cattle at heavy expense for feed and labor.

In addition to the feed and labor expense, death losses on the whole were heavy during the latter part of the winter of 1919-20. It was not difficult to borrow money to buy feed, because the opinion prevailed that market prices would remain high. From the best information available, the average loan on cattle in the fall of 1919 was approximately

$20 per head. Local values at the time were around $65 per head. The wintering charge for 1919-20 increased the indebtedness to approximately $35 per head. The decline in prices early in 1920 decreased the value of cattle to approximately $30 to $35 per head. From a financial standpoint, the situation was very critical.

Poor crop yields occurred in various districts of low rainfall from 1916 to 1922. In 1918, 1921, and 1922 seed loans were made by the Government in those districts that had suffered crop failures. In the early part of 1920 the financial condition of farmers was scarcely more favorable than that of cattlemen. The 6-years' depression resulted in a heavy out movement of farmers, many of whom had come into the region in recent years.

The five years 1920 to 1924, inclusive, were very critical years for the cattlemen, regardless of the fact that range conditions were, on the whole, fairly good. Cattle prices were low compared with the prices of commodities which ranchmen had to purchase. The price of labor did not decline in proportion to the decline in the value of ranch products. Taxes voted during the war period remained high. The indebtedness was comparatively heavy in 1920 and interest was burdensome. The necessity for meeting the indebtedness compelled many cattlemen to go out of business entirely and others to decrease their herds materially.

The low prices of range cattle as compared with the general price level of all commodities is shown in Figure 6. The base period for this comparison is the five years 1909-1913. Considering the average price during this period as 100, it is seen that range-cattle prices in 1925 were 33 percent above the average of this five-year period, whereas the general level of all prices in the United States was 62 percent above the 1909-1913 level. This disparity in the price of range cattle and the general price level has continued since 1919.

There may be some question as to why the five-year period 1909-1913 was used as a base, inasmuch as the price of range cattle in relation to the price of other things was somewhat higher during this period than during the previous 30 years. It must be remembered that prior to 1900 range cattle had been produced primarily under free range conditions; and as this free range was being taken up by homesteaders for farming purposes, the costs of raising range cattle were increasing because of competition with grain farming for the use of land, increased taxation, and the cutting up of the open range. With these things in mind it would seem that the 1909-1913 basis of relationship between the price of range cattle and all commodities is more nearly equitable for present conditions than the relationship which existed prior to this period.

The actual prices of western range cattle at Chicago since 1878 were divided by the index of wholesale prices of all commodities, the five-year period 1909-1913 being used as a base. This shows that the price of western range cattle deflated in this manner was lower in 1925 than it had been from 1907 to 1920. On this basis the price of cattle in 1920 was lower than it had been in the 30 years previous.

Of the occurrences of the last 25 years that may have a lasting effect on future ranching in this region, the homesteading of the range stands out as the most important. It is evident that the progress of homesteading was too rapid and did not permit organization of the newly established units with reference to the natural adaptation of the region. Probably the most beneficial result has been that the title to land has passed to individuals who can lease or sell it. In its present condition of wide ownership, this range land can not be expected to support a stable ranching industry. The cattle industry must assume some degree of stability if institutions are expected to finance it.

As a result of the economic situation briefly referred to, the cattlemen of the region at present are confronted with three major problems: (1) Acquirement of farm or range land by purchase or lease and its organization into stable productive units, (2) production and marketing of the class and quality of cattle demanded by consumers, and (3) care and improvement of the native range in order that the producing capacity of the unit may be increased.

The records of the ranches have been grouped for this report with respect to the number of breeding cows on each ranch at the beginning of the year April 1, 1924. Since the breeding cow is the productive unit on cow ranches, the use of that unit reduces all the ranches to a comparative basis. In referring to breeding establishments, the term "breeding cows" is more generally used in stating the size of the ranch in the range country than is any other term. The acres of land necessary to carry a cow, the percentage calf crops, the length of the grazing season, and all other factors that influence beef production may vary within wide extremes in the different range regions of the Western States, but the productive unit as referred to remains the same. On ranches which carry a large proportion of steers or livestock other than cattle, the number of breeding cows may not be a perfect measure of size of ranch; but in most cases it meets this purpose satisfactorily, especially in regions where public domain and National Forest range are used extensively.

The average carrying capacity of grazing land in this region seemed to be about 20 acres per animal, judging from the ranches that were reported as being "normally stocked" and operated on fenced range. About 1 acre of farm land per head was required to provide hay or other winter feed. The average amount of roughage fed to 41,154 head of mixed cattle was 0.8 ton per head or the approximate yield of 1 acre of hay.

A classification of ranges in the region on the basis of ownership gives some indication of the use usually made of the various classes. Where a sufficient acreage is owned, privately owned range is used for summer and winter grazing. Leased range is operated in most cases as if owned. The limited amount of National Forest range in the region is used for summer grazing. The public domain and the abandoned

and unfenced homesteads, both of which constitute the "free range," is used to a greater extent for summer than for winter grazing; but in some favorable areas, the open range furnishes considerable winter grazing, notably in the Bad Lands area of North Dakota. That it is not uncommon to find ranchmen who are operating on several of these classes of range, especially among the smaller-sized groups.

Range livestock production is not a business to be entered into with the expectation of high net returns within a period of a few years. Systematic or conservative operation necessitates taking care of the native grasses. On practically every range there is constant competition between the various plants for predominance. Continuous close grazing of the most desirable grasses will result in the less desirable becoming predominant. Therefore, overstocking is false economy in a plan of ranch operation that is expected to be continued over a period of years. Excessive overgrazing for two years in succession may result in greater damage to the range than can be overcome during the following four years under approved methods of range improvement.

Among the influences that prompt ranchmen to overstock are extremely low market prices which encourage an attempt to avoid sacrifice sales and financial obligations, not necessarily pressing in nature, but sufficient in amount to encourage carrying a larger number of cattle for collateral. It seems that some of the ranchmen from whom records were obtained are acting in accord with the latter reasoning. The reaction of some ranchmen toward a favorable market has been to carry more livestock than the range would normally carry for greater production to sell on an expected higher market. From the many examples of adversity resulting in part or entirely from overstocking in the western range regions, it is very evident that the chance is not worth taking.

The systems of grazing that may be considered in this region are continuous, deferred, and rotated. At present continuous grazing, which means use of the same range throughout the summer season or year, is practically the only system employed. Deferred grazing is employed in part by some operators who withhold grazing of certain pastures until the grass has matured. The use of bluestem range late in the summer for hardening steers is an example of this system. Deferred and rotated grazing, which necessitate division of the range into areas each of which is deferred in turn, are not generally practiced.

Woodward, T. E., J. B. Shepherd, and R. R. Graves. 1933. Feeding and Management Investigations at the United States Dairy Experiment Station at Beltsville, Maryland - 1932 Report. USDA, Misc. Publ. #179. 50 pp., illus.

For several years a pasture experiment has been carried on at Beltsville by the Bureau of Dairy Industry in cooperation with the Bureau of Plant Industry, to compare rotation grazing with continuous grazing, fertilized with unfertilized pastures, and Reed canary grass with a pasture mixture of grasses and clovers. The general layout of the experimental pastures and the methods of grazing them are illustrated in figure 5.

The 12-acre field, divided into 6 pastures for rotation grazing, was seeded in the fall of 1928 and reseeded in the spring of 1929 with the pasture mixture. The 3 fields of about 4 acres each, used for continuous grazing, were all seeded in the spring of 1929, 2 with the pasture mixture and 1 with Reed canary grass. The rotation pastures and one of the continuously grazed pastures seeded to the pasture mixture were fertilized yearly by the method described later. The rotation system used was as follows: Each of the pastures in turn was grazed with milking cows for about 4 days, followed by young stock for the same number of days, the cows being moved on to the next pasture. In this way only 2 of the 6 pastures were being grazed at the same time. An attempt was made to graze all the pastures equally close by taking animals off or putting additional animals on the pastures and to balance the different groups in breed, age, weight, condition of flesh, stage of lactation, and production of milk. In addition to pasture, hay and grain were fed to the cows in the amounts believed necessary to maintain production and body weight, and to young stock in the amounts required to support normal gains in weight.

The grazing data for the season of 1929 were not used because the rotation pastures seeded in the fall made a more vigorous early growth than the continuously grazed pastures seeded in the spring. The results for the season of 1930 have been given in a previous publication together with a more detailed description of the plan of the experiment.

RESULTS FOR THE SEASON OF 1931

The season of 1931 was on the whole a very favorable one for growth of pasture plants at Beltsville, Md. Although the grass was somewhat slower in starting growth than in the spring of 1930, probably on account of the low precipitation in April 1931 and the drought of 1930, the grazing in the latter part of the season was much better than it usually is at that time of year, because of favorable rains during the period May to August. As the pasture of Reed canary grass, however, had a very unsatisfactory stand, the data on that pasture are omitted, although it was grazed throughout the season. The precipitation in 1931 from March to October, inclusive, and the average precipitation for 45 years are shown in table 17.

TABLE 17 -- Precipitation in inches by months at or near Beltsville, Maryland, during the growing seasons of 1931 and 1932, and the 45-year average precipitation.

	March	April	May	June	July	August	September	October
45-year average[1] . .	3.46	3.59	3.74	3.96	4.11	3.93	3.22	2.64
1931[2].	3.84	2.20	3.87	4.75	4.58	7.96	1.22	1.16
1932[2].	5.59	2.45	4.94	3.72	2.70	1.53	3.67	6.38

[1]College Park, Maryland, record.
[2]Beltsville, Maryland, records.

The basis on which the yields of the different pastures are compared is the digestible nutrients produced, as calculated from the milk yield and the estimated feeding requirements of the animals on each of the pastures. When the results in 1930 were reported (14) there was no experimental evidence available showing the digestible nutrients required by dairy cattle in making gains in weight. Since then Eckles and Gullickson (4) have published results of their work on nutrients required for normal gains of young cattle, which check very well with the figures that were used in the 1930 report, although these investigators found that the maintenance requirements of young stock were greater and the growth requirements were less than had been estimated in the 1930 report. In this experiment, since the data for maintenance and for gains or losses in weight of the cows were included with those of the heifers grazing the same pastures, and since no reliable basic figures are available for calculating accurately the nutrients required for gains in weight of milk cows, it was thought best to make no change from the method used in the 1930 report. In this method 7,925 pounds of digestible nutrients per day per 1,000 pounds of live weight is allowed for maintenance and 3 pounds of digestible nutrients for each pound of gain in weight.

The average number of acres required to pasture 1 milking cow and 1 heifer during the season of 1931 on the different pastures, except the one seeded to Reed canary grass, based on a grazing period of 164 days, was as follows:

	Acres
Fertilized, rotation-grazed pastures.	1.37
Fertilized, continuously grazed pasture	1.53
Unfertilized, continuously grazed pasture . . .	2.14

Table 18 gives a record on a per acre basis of the days of grazing, production of milk and butterfat, gains and losses in live weight, supplemental feed, and nutrients for the different pastures by months for the grazing season of 1931. The digestible nutrients required by the cattle for milk production were estimated from the Savage standard and the nutrients for maintenance and for gains in weight by the method

previously given. From the total requirements is deducted the number of pounds of nutrients in the supplemental feed, giving the nutrients provided by grazing; and to this amount is added the number of pounds of nutrients contained in the hay clipped from the pastures to obtain the total nutrients credited to the pastures.

The fertilized, rotation-grazed pastures yielded 23 percent more nutrients than the fertilized, continuously grazed pasture, which, however, yielded 27 percent more nutrients than the unfertilized, continuously grazed pasture.

SUPPLEMENTAL FEED

In estimating the quantities of supplemental feed that were to be given to the cows during May, it was assumed that the pastures would provide enough nutrients for maintenance and the production of about 1 pound of butterfat per cow per day. Holstein cows yielding 30 pounds or less of milk a day and Jersey cows giving 20 pounds or less were not given any supplemental feed in May. For all production in excess of these quantities, supplemental feed was given in quantities specified by accepted standards; it consisted chiefly of grain, although some cows got a little hay.

Pasture and 5 pounds of hay per cow per day were expected to provide for maintenance and for the production of 24 pounds of Holstein milk or 18 pounds of Jersey milk a day in June; for maintenance and 18 pounds of Holstein milk in July, the Jerseys having been taken off pasture; for maintenance and 10 pounds of milk early in August and 20 pounds later after rains had freshened the grass; for maintenance and 25 pounds of milk in September. Grain was fed to provide for all production above the quantities stated. During August, September, and the first part of October, the cows gained back most of the loss in weight sustained in the first part of the season. The young stock were not given hay. The hay fed to the cows was mostly alfalfa and some soybean hay.

The average rate of feeding grain for the whole season varied with the different pastures from 1 pound of grain for about 4½ pounds of milk to 1 pound for about 5½ pounds of milk and from less than 5 to more than 6 pounds of grain for each pound of butterfat produced. The grain mixture fed consisted of 100 pounds each of hominy feed, wheat bran, and ground oats, and 50 pounds each of linseed meal and cottonseed meal. In addition to the grain mixture, many of the heifers received either sprouted oats or cottonseed meal. Of the total digestible nutrients required by the cows for maintenance, milk, and gain in weight, and by the heifers for maintenance and gain in weight on the different pastures, the percentages provided by the grain and hay were as follows:

	Percent
Fertilized, rotation-grazed pastures.	33
Fertilized, continuously grazed pasture . . .	31
Unfertilized, continuously grazed pasture . .	29

DECLINE IN MILK PRODUCTION

Six cows were on pasture continuously for 160 days. All of these had freshened in February or March. While the number of cows is too small for comparison of the different pastures in maintaining milk production, it is interesting to note that the production of these six cows declined from a daily average of 51 pounds for the first 10-day period to 23 pounds for the last 10-day period of the grazing season. This decline, amounting to 55 percent in 5 months, is much greater than would be expected under winter conditions, though it may be typical of what usually happens under the summer conditions prevailing at Beltsville when cows must obtain most of their subsistence from pasture.

CLIPPING THE PASTURES

The aim was to keep all the pastures grazed to the desired height at all times by increasing or reducing the numbers of animals on the pastures. This plan succeeded very well except when the Kentucky bluegrass in the pasture was going to seed. Its seed stalks shot up so rapidly that even heavy grazing would not keep them down; also, the cattle avoided the patches where the grass had headed and grazed the short grass instead. In order to get rid of the taller grass and thus induce more uniform grazing, the pastures were clipped to a height of about 4 inches. The clippings were made into hay and weighed; and from the weights and the moisture determinations, the quantity of air-dry hay was estimated. The hay was assumed to contain 50 percent of digestible nutrients.

The air-dry hay removed per acre from the different pastures was as follows:

	Pounds
Fertilized, rotation-grazed pastures	419
Fertilized, continuously grazed pasture	258
Unfertilized, continuously grazed pasture . . .	254

ROTATION GRAZING AS COMPARED WITH CONTINUOUS GRAZING

The 12-acre rotation-grazed pasture and one of the 4-acre continuously grazed pastures were similar in other respects, being seeded to the pasture mixture and regularly fertilized. The rotation-grazed pastures were credited with the production of 2,567 pounds of digestible nutrients per acre (table 18), and the continuously grazed pasture was credited with 2,083 pounds per acre. The difference of 484 pounds of nutrients would be equivalent to the nutrients in 938 pounds of alfalfa hay. If the cost of raising or of buying alfalfa hay is known, the money values of the increase due to rotation grazing can be readily estimated. Apparently if such an increase should be maintained over a number of years, it would more than repay the cost of dividing a pasture into several smaller pastures for rotation grazing. In the case of the fertilized pastures, the increase in yield of nutrients obtained by rotation grazing was 23 percent. If this same percentage of increase were to be applied to poor pasture, the advantage of rotation grazing

would be less, as the cost of the additional fencing required for rotation grazing may approach or even exceed the value of the increased nutrients secured from a poor pasture as a result of rotation grazing. Rotation grazing is therefore likely to be more advantageous on good than on poor pastures.

CLUMPINESS OF THE PASTURES

One of the advantages claimed for rotation grazing is that the grass is eaten down to a more uniform height. The grass on about half or more than half of the continuously grazed pasture was more uniform in height than the grass on any of the rotation-grazed pastures. The other half of the continuously grazed pasture was almost as uniformly grazed as any of the rotation-grazed pastures. Figures 6 and 7, showing photographs taken in September 1931, are intended to show the uniformity of grazing in the two pastures.

FERTILIZATION

Fertilizer was applied to one of two 4-acre pastures which otherwise had the same treatment, both being seeded to the pasture mixture and grazed continuously; also to the rotation-grazed pasture. Four hundred pounds of superphosphate (16 percent), 100 pounds of muriate of potash (50 percent), and either 400 pounds of nitrate of soda (15 percent) or 300 pounds of sulphate of ammonia (20 percent) were applied per acre each year.

The superphosphate and muriate of potash were applied in late winter or in early spring a month or more before the cattle were turned on the pastures. One fourth of the nitrogen fertilizer was applied at the same time as the superphosphate and potash and the remainder in three equal applications at intervals up to midsummer. The cost of the fertilizer was $12.19 per acre. The labor of applying the fertilizer was 7½ man-hours and 1½ horse-hours per acre.

The difference between the digestible nutrients credited to the 2 fertilized and unfertilized pastures that were similarly seeded and grazed was 449 pounds per acre. This quantity of nutrients would be contained in 870 pounds of alfalfa hay. If alfalfa hay could have been purchased or raised for $28 a ton, it is estimated that the money spent for fertilizer might just as well have been spent for hay. If alfalfa cost more than $28 per ton, the advantage would be with fertilizer at $12 per acre; but if hay was less than $28, it would be cheaper than fertilizer.

It is not the intent of the writers to depreciate the value of fertilization, for it is well-known that a fertile soil is, as a rule, a prerequisite to profitable farming. However, the wisdom of applying large quantities of high-priced nitrogenous fertilizers which have only a short-time effect and that only in the presence of considerable moisture may well be questioned. At present it appears that whatever fertilizing practice is the most profitable in growing general farm crops is likely to be the most profitable in growing pasture plants.

THE GROWTH OF WEEDS

Weeds were not a serious problem in any of the pastures. The fertilized pastures and the canary grass pasture were almost entirely free from weeds. However, in one end of the unfertilized pasture seeded to the grass mixture, there was a considerable growth of ragweed and cockleburs.

RESULTS FOR THE SEASON OF 1932

The first half of the 1932 season was in general favorable to the growth of pasture plants at Beltsville, but in the second half the growth during July and August was quite slow. The record of precipitation (table 17) in 1932 shows that the precipitation in July and especially in August was unusually low as compared with the 45-year averages shown for these 2 months. The cattle were turned on the fertilized pastures April 16, 12 days earlier than in the season of 1931, and were taken off October 18, 7 days later than in 1931, a period of 186 days on the calendar. The first 6 days the cattle were pastured only in the daytime. Therefore, the pasture season was equivalent to 183 days on a 24-hour basis.

Since the stand of Reed canary grass in 1931 was rather poor and failed to improve materially with pasturing, cattle were not put on this pasture in 1932. The canary grass was cut in July, after it had formed seeds, and yielded 2,048 pounds of field-cured hay to the acre. Though the stand seemed to have improved a little, it was still unsatisfactory.

The average number of acres required to pasture 1 milking cow and 1 heifer for the season of 183 days on each of the other pastures was as follows:

	Pounds
Fertilized, rotation-grazed pastures	1.45
Fertilized, continuously grazed pasture. . . .	1.73
Unfertilized, continuously grazed pasture. . .	2.50

While these figures show the relative carrying capacity of the different pastures, they do not mean that the number of acres stated would keep 1 cow and 1 heifer continuously on this pasture throughout the season. As a matter of fact, the number of animals on the pastures varied greatly during the season, depending on the rate of growth of the grass. For example, the rotation-grazed pastures had 17 cows and 17 heifers on them during most of May and only 3 cows and 3 heifers on them during August. Although in the previous years some of the grass formed seed heads in May and was clipped and made into hay, in 1932 the grass was kept grazed so closely so that none required clipping.

Table 19 shows a record, on a per acre basis, of the grazing, grain fed, production of milk and butterfat, and gains and losses in live weight, and nutrients for the three pastures during the grazing season of 1932.

SUPPLEMENTAL FEED

The quantities of supplemental feed that were to be given the cows and heifers throughout the season were estimated in the same way as in 1931. In 1932 no hay was given to the cows on pasture for two reasons. One was that a digestion experiment (p. 18) had indicated that the addition of hay to a ration of grass did not improve the ration; the other was that nutrients were provided more cheaply in grain than in hay under the conditions at Beltsville. The average rates of feeding grain to the cows on the different pastures ranged from 1 pound of grain for each 4.5 pounds of milk to 1 pound for each 4.9 pounds of milk, or from 5.6 to 6.0 pounds of grain for each pound of butterfat produced. The grain mixture fed was similar to the mixture that was fed the previous season.

For the animals grazed on the different pastures, the supplemental feed provided the following percentages of the total digestible nutrients required by the cows for maintenance, milk, and gain in weight, and by the heifers for maintenance and gain in weight:

	Percent
Fertilized, rotation-grazed pastures.	22
Fertilized, continuously grazed pasture	24
Unfertilized, continuously grazed pasture . . .	18

The amount of supplemental feed given in 1932 was less than in 1931, mainly because the cows produced a little less milk and because the heifers did not eat nearly as much grain as in 1931.

The average daily milk production of the cows in 1931 on all the pastures was 30 pounds; in 1932, 26 pounds. In 1931 the heifers ate an average of 4 pounds of grain a day; in 1932 they ate only 2.2 pounds.

COMPARISON OF ROTATION WITH CONTINUOUS GRAZING

The yield of the fertilized, rotation-grazed pastures exceeded that of the fertilized, continuously grazed pasture by 18 percent, as compared with a 23 percent increase in 1931, and exceeded that of the unfertilized, continuously grazed pasture by 48 percent as compared with an increase of 27 percent in 1931. The rotation-grazed pastures yielded exactly the same quantity as in 1931, the fertilized, continuously grazed pasture a little more, and the unfertilized, continuously grazed pasture a little less.

A comparison of the 2 pastures that were treated alike, except in method of grazing, shows that the rotation-grazed, fertilized pastures were credited with 2,567 pounds of digestible nutrients per acre in both years; and the continuously grazed, fertilized pasture was credited with 2,171 pounds per acre in 1932, as against 2,083 pounds the year before. Therefore, the increase due to rotation grazing alone in 1932 was 396 pounds of digestible nutrients per acre or a little less than in 1931. Expressed in terms of hay, 767 pounds of average alfalfa hay would provide 396 pounds of digestible nutrients.

Although the rotation-grazed pastures have consistently yielded more nutrients than the continuously grazed pastures during the 3 years of this experiment, these results must not be considered conclusive evidence of the superiority of rotational grazing. In laying out the experimental fields, due consideration was given to their productiveness with the object of having them all equal in this respect.

The question has arisen, however, whether the field used for rotation grazing might not be a little better than the fields used for continuous grazing in regard to the lay of the land and the character of the soil. For this reason, it is planned to reverse the system of grazing -- that is, to graze the rotation pastures continuously and the continuously grazed pastures in rotation. By so doing it is hoped to determine conclusively whether any increase in yield of pastures may be expected by grazing in rotation in this climate, under the conditions of this investigation.

WEEDS

All of the pastures were remarkably free from weeds in 1932. While the unfertilized pasture had a considerable growth of weeds in one end in 1931, it had practically none in 1932. Observations on closeness of grazing in 1932 corroborate those of the previous year, that the grass of the continuously grazed pasture was grazed down as uniformly as that of the rotation-grazed pasture.

FERTILIZATION

On the fertilized pastures, the method of applying the fertilizers and the kinds and quantities used per acre were the same as in 1931. The cost, however, was $9.75 per acre as against $12.19 in 1931. Comparison of the results for the fertilized, continuously grazed pasture and the unfertilized, continuously grazed pasture shows that the increase in yield per acre due to use of fertilizers was 701 pounds of digestible nutrients, an amount contained in 1,359 pounds of average alfalfa hay. In 1931 the increase per acre was 449 pounds of nutrients, an amount contained in 870 pounds of average alfalfa hay. The value of the fertilizer used in 1932 in terms of hay would be equivalent to $14.35 per ton of alfalfa. If the hay could have been purchased or raised for less than this figure, it would have been cheaper to use than the fertilizer.

This method of arriving at the economic value of a pasture treatment is different from the methods used by most investigators. Some evaluate the treatment on the basis of the money value of the increase or decrease in milk production per acre. In other words, they consider only the extra milk per acre obtained by using fertilizer, without regard to the cost of feed that would produce an equivalent amount of milk. It appears to the writers that any increase in the yield of pasture grass should be compared in value with that of some other feed or feeds which would replace the increased quantity of grass produced. In doing this, the costs of each should be arrived at in the same manner.

If the cost of pasture grass is figured at the actual cost of raising the grass, then the feed or feeds to be compared with the pasture should be figured at the actual cost of raising these feeds. It is obviously unfair to add a profit above the cost of production in one case and not in the other. For example, it has been found that applications of nitrogenous fertilizer stimulate the growth of grass in the spring so that it is ready for grazing earlier than grass which is not so fertilized. This early grazing has been evaluated by the saving it effects in barn feeding. The feeds fed in the barn were figured at market prices rather than cost of production, but the grass was assumed to cost only as much as the fertilizer applied.

Woodward, T. E., J. B. Shepherd, and M. A. Hein. 1938. The Hohenheim System in the Management of Permanent Pastures for Dairy Cattle, USDA Tech. Bulletin #660, 33 pp., illus.

The Hohenheim system of pasture management is so called because it was first introduced at Hohenheim, Germany. A description of this system is contained in a review of the original experiment, which appears to have been written by a representative of the Journal of the Ministry of Agriculture for Great Britain. The following comments were taken from that review:

> The original Hohenheim experiment established by Dr. Warmbold included 69 acres of pasture divided into 10 enclosures from 1 to 10 acres each. The experiment started in 1916 when the pasture required 1.4 acres to maintain a 1,000-pound cow from the end of April to the beginning of October.
>
> The fertilizer applied annually under the Hohenheim system was 107 pounds per acre of pure nitrogen (500 pounds sulphate of ammonia equivalent) besides phosphate and potash. At the beginning of the treatments, 36 pounds of phosphoric acid (260 pounds of superphosphate equivalent) and 80 pounds of potash (200 pounds 40 percent potash salts equivalent) per acre were applied to the pasture. Later, the phosphates and potash were reduced but the amount of nitrogen continued the same.
>
> Phosphates and potash were applied in autumn. Half of the nitrogen in the form of sulphate of ammonia was applied about February 1 and the other half in three separate applications, usually as area, in May, June, and July. The area seemed to have some special advantage for summer application. Lime was applied at intervals of 6 years, at the rate of about 900 pounds per acre.
>
> A requirement of the system is that the grass must be grazed in a young, leafy stage. If the herd was unsufficient to keep down the vigorous growth at a certain time of the year, part of the pasture was cut for hay. The first "bite" of each enclosure was obtained by the best milk cows; after 2 or 3 days on a plot, these cows were followed by lower yielding cows or by dry cows and stock cattle.
>
> Also, it appears that from 1918 onwards the heavy application of fertilizers resulted in a carrying capacity of 0.5 acre per cow for the grazing season as against 1.4 acres required at the beginning of the experiment.

American investigators are not in agreement as to what practices constitute all the essential phases of the Hohenheim system. They do, however, agree that two of the main practices involved are (1) rotating the cattle over separate parts of the same pasture, and (2) liberal application of fertilizers, particularly those carrying nitrogen. Some maintain that dividing the herd according to the quantity of milk produced and then giving the highest producing cows the first chance at the fresh pasturage is an additional essential part of the system. Others assert that harvesting hay from some of the pasture fields early in the season is also an integral part of the system. It appears certain that all of these variations were actually practiced by Dr. Warmbold at Hohenheim.

The Hohenheim system of pasture management is primarily intended for dairy cattle, although other livestock may be benefitted also. Its principal purpose is to increase the yield of nutrients for milk and butterfat production from the pasture, by maintaining the herbage in an immature, rapidly growing stage throughout the growing season, as well as to increase the total yield of nutrients obtained by the cattle and other livestock.

In view of the apparent success of the Hohenheim system in Germany and the favor with which it or similar systems were regarded in some other countries, notably the Netherlands, England, and New Zealand, it seemed desirable to conduct an investigation to determine whether or not the Hohenheim system is adapted to conditions that prevail in the United States. In the countries mentioned, the climate and soil are excellently adapted to the growing of pasture plants. The cool summer weather prevents excessive drying of the soil and lessens the loss of organic matter from the soil. While the total precipitation in those countries may not be any greater than over a great part of the United States, the rains are more frequent as well as less violent. Because of the high content of organic matter in the soil and the gentleness of the rains, there is much less surface run-off than in the United States.

Agriculture is less intensively practiced in this country, the land values are lower, and high yields per acre are not so essential to success. The densely populated European countries cannot raise enough food on their land to feed the inhabitants.

The literature regarding the influence of fertilizers on pastures is too voluminous to review. In general, it can be said that fertilizers increase the yields, thicken the turf, and discourage the growth of weeds. They do not generally improve the uniformity of growth from one part of the pasture season to another. Applications of nitrogen not only increase the nitrogen content of the herbage but also may promote the growth enough so that the pastures will be ready for grazing as much as 3 weeks earlier than those not receiving such applications. In many cases it is reported that applications of nitrogen discourage the growth of legumes.

The study of the Hohenheim system described in this bulletin was conducted on the experimental dairy farm at Beltsville, Maryland. The Bureau of Dairy Industry stocked and managed the pastures during the experiment and measured the yields of pasture nutrients with dairy cattle. The cattle used in grazing the pastures were from the Bureau's experimental dairy herd at Beltsville. The Bureau of Plant Industry prepared the soil of the fields used, seeded and fertilized the pastures, carried out plant-population studies, and made chemical analyses of the herbage.

The original plan was to establish a 12-acre pasture, then divide it into six equal parts, and manage it as advocated by the sponsors of the Hohenheim system. That is, the six units were to be grazed in rotation and the whole pasture was to be fertilized during the entire period of the experiment. The work had barely started when it was decided that this plan was inadequate for two reasons. One was that no control pasture had been provided. The other was that, if the Hohenheim system proved advantageous, there would be no way of telling whether it was advantageous because of the method of grazing or because of the fertilizer applications. For these reasons, two 1-acre pastures were added to the experiment. Both 4-acre pastures were to be grazed continuously, one was to be fertilized and the other unfertilized, for the duration of the experiment. This will explain why the three experimental pastures are not all the same size and why the seedlings were not all made at the same time.

The fields used for the three pastures were selected after due consideration had been given to the productivity of the soil and its previous treatment. The soil in all fields was Sassafras silt loam; all fields had received generous applications of lime and stable manure in previous years; and all had good stands of alfalfa when plowed up for seeding to a pasture mixture. The same pasture mixture was used for all three. It was expected, with pastures so much alike, that they could be compared directly year by year and for the entire period of the experiment. If the plan outlined for managing the pastures could be followed throughout the experiment, then comparison of the fertilized pastures, A and B, one to be grazed in rotation and the other continuously, would show the effect of rotation grazing; a comparison of the fertilized pasture B and the unfertilized pasture C, both to be grazed continuously, would show the effect of fertilizer applications; and a comparison of pasture A (fertilized and grazed in rotation) with pasture C (unfertilized and grazed continuously) would show the combined effect of rotation grazing and fertilization. The comparisons could not be made as simply as this, however, because several adjustments became necessary.

For example, in the management of pastures A and B, it appeared desirable after results for 3 years (1930-33) had been studied to interchange the methods of grazing them because of the obvious superiority of the turf in pasture A. This superiority was attributed either to a more fertile soil or to a more favorable topography. Hence, pasture A (12 acres)

was rotationally grazed for 3 years, then grazed continuously as a single pasture for 3 years. Pasture B was grazed continuously for 3 years, then divided into six equal (2/3-acre) units and rotation-grazed for 3 years. Although the interchange mentioned does not complicate materially the comparison between A and B to determine the effect of the method of grazing, it does necessitate certain adjustments when other comparisons are made to determine the effect of fertilizer applications when used alone or in combination with rotation grazing.

The effect of using fertilizer in this experiment was to be determined by comparing pasture B, fertilized, and C, unfertilized. There two pastures were both made from a field which had been uniformly treated as regards the crops grown, and the manure, lime, and fertilizer applied for a period of 15 years before this investigation began. Also, the topography of the two pastures is similar. Not withstanding their great similarity, they cannot be compared directly to determine the effect of fertilizer applications because of the change in method of grazing pasture B. Pasture C was continuously grazed during the 6-year period; but pasture B, during 3 of the 6 years of experimental work, was grazed in rotation. Hence, the yields of pasture B must be adjusted to the basis of continuous grazing before the comparison can be made between B and C for the influence of fertilizer.

Furthermore, in order to arrive at the combined effect of fertilizers and rotation grazing, two courses are open. One way would be to estimate the difference in yields due to the difference in natural productivity between pastures A and C (assuming that B and C were equal in natural productivity), and deduct this difference from the yield of pasture A; then make an additional adjustment for the 3-years' continuous grazing of pasture A. After the results for pasture A have thus been converted into terms of rotation grazing and fertilization for the 6-year period, the comparison can be made between A and C.

The other course is to convert the results for the 3 years of continuous grazing of pasture B into terms of rotation grazing and consider this as a rotation-grazed pasture for the 6 years. Then the comparison can be made between pasture B, as a rotation-grazed fertilized pasture, and pasture C, as a continuously grazed unfertilized pasture. This latter course is preferable because it is simpler, though both should lead to the same ultimate result.

In order to obtain definite information on the plant composition of the pasture grass and the relative amounts of the different kinds of plants in the ground cover on the fertilized rotationally-grazed pasture, the fertilized continuously grazed pasture, and the unfertilized continuously grazed pasture, studies were made of the plant population on selected areas during each year of the experiment.

A permanently marked quadrat, containing 9-square feet, was located in each of three rotation units (2, 3, and 1) of pasture A and one in each of pastures B and C. These quadrats were located as nearly as possible on representative areas, except the one in unit 4 of pasture A. To study the rapidity of pasture plant establishment under adverse conditions,

this quadrat was placed on an area which had suffered severe winter injury in the seeding year. All quadrats were open and subject to the same grazing and tramping effect as the remainder of the pasture.

When readings were taken on the quadrats to facilitate more accurate and rapid estimates, they were divided into square-foot areas, giving a total of nine readings on each quadrat. The estimates of the nine areas were totaled and the average calculated per square foot. In 1929 plant counts were made of the individual species. After that year accurate plant counts could not be obtained without disturbing the turf, and the individual composition was measured by estimating the area covered by each species. Also, the area of bare ground was estimated. The readings were taken in May shortly after grazing was started and in October before it was discontinued. These two readings gave an accurate picture of the changes in the sward; but they did not give an accurate estimate of the contributions of the annual lespedezas, since the readings were taken before lespedeza was established in the spring and after its maturity in the fall. Observations were made at the time lespedeza was making its maximum growth during the season, to determine its contribution to the herbage.

Pasture A was grazed according to the so-called Hohenheim system or rotation-grazing method; and pastures B and C were each grazed continuously as one unit for the first three seasons, 1930-32. During the next three seasons (1933-35) pasture B was grazed by the rotation method, and pastures A and C were each grazed continuously as one unit.

Each of the six units of the rotation-grazed pasture was first grazed by milking cows and then by young stock. Two units were thus being grazed while the other four were recuperating, so that each unit was grazed one-third of the time. By shifting all cattle every 4 days (the young stock being placed on the unit just vacated by the cows), 16 days were allowed for recuperation, which was considered about right in good growing weather. In dry weather the recuperative period could have been much longer and the shifts less frequent without the grass becoming too mature.

Animals were put on or taken off the three different pastures (A, B, and C) in such numbers as would result in the pastures being grazed equally close and also heavily enough so that but little of the grass would grow up and remain uneaten. Clumps of uneaten grass could not be avoided in any of the pastures. Particular attention was directed toward having all three pastures grazed equally close at the end of the season. The cattle were turned on the pastures in the spring when the grass was 3 to 6 inches high. They were taken off usually a week or so after the first killing frost in the fall.

The cattle used were Holstein-Friesians and Jerseys. About as many heifers as milking cows were used. An effort was made to have the groups of cattle on the three different pastures (A, B, and C) comparable with reference to the breed, age, size, milk production, and stage of lactation. Cows recently fresh and animals nearing parturition were not included.

The aim was to give the cattle enough supplementary feed to keep the heifers gaining, to maintain the weights of the cows, and to prevent any undue decline in milk production. At the same time it was desired to have the cattle get as much of their total nutrient requirements as possible from the pasturage. The quantity of supplementary feed given was gaged by the condition of the pastures, the gains being made by the heifers, the gains or losses in weights of the cows, the quantity and fat percentage of the milk, and the decline in daily milk production. Concentrates (18 percent average protein content) were used for the most part as the supplementary feed. The quantity varied from none to as much as or more than would be fed in the stable during the winter. In general, for the first month or so in the spring, cows producing less than 1 pound of butterfat a day received no supplementary feed whatever, and those producing more were fed enough concentrates to provide the nutrients required for all the butterfat produced over and above 1 pound a day. As the pasturage became poorer, the flow of milk that it would sustain became less; and concentrates were provided for all production above 0.75 pound, then 0.5 pound of butterfat a day, and sometimes in the driest part of the summer for all production; the pasturage being expected to provide only the nutrients required for maintenance.

SUMMARY

Three fields of 12, 4, and 4 acres, respectively, in a good state of productivity were used in an investigation of the Hohenheim system of pasture management for dairy cattle.

A good 2-year-old stand of alfalfa on all the fields was plowed under, and the fields were seeded with a complex pasture mixture of grasses and legumes.

One pasture was divided into six equal units, heavily fertilized each year with a complete fertilizer, and the units were grazed in rotation; another pasture was fertilized in a similar manner but was grazed continuously; the third pasture was unfertilized and grazed continuously.

After 3 years, the method of grazing the first two pastures was reversed; and the experiment with all three pastures was continued for another 3 years.

Except for 1 dry year, 1930, the climatic conditions were not very different from the average of 18 years.

On the two fertilized pastures, the growth of the grasses suppressed the legumes; and in a few years Kentucky bluegrass was predominating. Orchardgrass and redtop were the most prominent of the other grasses remaining. On the unfertilized pasture most of the grazing in spring was furnished by Kentucky bluegrass, orchardgrass, and redtop, and in summer by common lespedeza.

Ungrazed clumps were as prominent in a pasture that was grazed in rotation as in a pasture that was grazed continuously.

The yields of herbage harvested by hand from protected spots were greater on continuously grazed pasture than on rotation-grazed pasture. The more frequent harvesting of the herbage is thought to have reduced the yield of rotation-grazed pasture. This result shows some of the difficulties that may be encountered and indicates the necessity for exercising particular care in measuring the yields of land harvested, caged areas, if such areas are to be used as the basis for measuring grazing yields.

The results obtained indicate that rotation grazing by dairy cows and heifers increased the yield of total digestible nutrients 10.4 percent, that heavy fertilization increased the yield 16.4 percent, and that both rotation grazing and heavy fertilization combined increased the yield 28.6 percent.

The fact that common lespedeza came into the unfertilized field to a much greater extent than into the fertilized fields is no doubt responsible in large measure for the relatively good showing of the former.

Heavy fertilization failed to improve the uniformity of carrying capacity throughout the grazing season.

It appears likely that on most dairy farms in the United States an increase of 10 percent in the yield of nutrients obtained from a pasture by rotation grazing would not be sufficient to justify the construction of permanent division fences of the usual type and to provide the necessary shade and water in each pasture. It is sufficient, however, under many conditions to justify the construction of a cheaper type of fence.

The application of large quantities of a complete fertilizer was not profitable.

Woolfolk, E. J. 1960. Rest-Rotation Management Minimizes Effects of Drought. USDA, FS, Pacific Southwest Forest and Range Experiment Station, Research Note #144, 3 pages.

1959 was one of the driest years on record in California. At Harvey Valley on the Lassen National Forest, where rest-rotation grazing management is being tested on a practical range allotment basis, only 9.6 inches of precipitation were recorded during the 12 months. The long-time annual average is 18.0 inches. Less than 6 inches came during May and June, the two most important growing season months.

This situation brought hardship to unknown numbers of livestock and caused early termination of grazing on summer ranges generally. At Harvey Valley, however, range cattle gave good weight gain performance and remained on the allotment for the usual four-month season.

Wet cows gained from one-sixth to one-third of a pound per head per day, depending on age, throughout the 120-day season. Calves gained from 1.4 to 1.6 pounds per day. Yearling heifers gained nine-tenths of a pound per day, and 51 head of yearling steers gained one pound each per day on the average.

Rest-rotation grazing each year divides the four-month season midway for two range units. One is grazed by 200 animal-units the first half of the season then rested, and the other is rested the first half and grazed by 400 the second half. A third unit is grazed season-long, by 300 the first half and 100 the second half.

This schedule provides a comparison of animal performance on season-long range versus animals moved to fresh range at mid-season. Ordinarily a move to fresh range at mid-season can be expected to carry some advantage to the animals. On the other hand, new surroundings can offset the benefits of the fresh range.

Yearling heifers and wet cows grazed season-long on the same range gained as much or more than similar animals moved at mid-season. Calves moved at mid-season, on the other hand, gained 5 to 8 pounds more than the others. This could have resulted from the maintenance of milk flow in the cows on fresh range. Considering all classes of cattle, season-long grazing gave the best animal performance during the past dry year.

Why did cattle on the same range season-long do so well during drought and as well as cattle moved at mid-season to fresh range? The range unit grazed season-long had the benefit of 7 years of rest-rotation management before 1959. Nearby ranges grazed season-long, year after year, provided less grazing and smaller cattle gains during droughty 1959.

Wootson, E. O. 1908. The Range Problem in New Mexico. New Mexico Agric. Exp. Sta. Bull. #66, 46 pp., illus.

The duties of Experiment Station Botanist have caused the author to make a critical firsthand study of the range problem in New Mexico -- an examination extending over several years and taking him over the greater portion of the Territory in a wagon or on horseback. He has thus come in close contact with the ranges and the stockmen and has endeavored to see the situation from as many points of view as possible. Being in no way financially interested in the industry, there was little chance of personal bias; the large view tends ever to fairness to the greatest number.

The difficulties arising from the present methods of conducting the business on an open public range were apparent on every side, and each individual was able to see clearly those immediately affecting himself and less certainly those of "the other fellow." The author endeavored to get the point of view of each, hoping to summarize the different ideas into something valuable not only to stockmen but in some measure to all the citizens of the Territory. Such conclusions must be in some degree applicable to similar conditions in other states and territories of the union, where stockraising on the public domain is now carried on.

Stockraising is one of the most important industries of the Territory and probably always will be. It is a large part of the "material basis" of our territorial civilization and is therefore of vital importance not alone to the men engaged in it but to every citizen of our civilization. Whatever will improve the conditions of the stock business and increase the output of beef and mutton, fat cattle and lambs, wool, mohair, and hides, or horses and mules, is bound to increase the general prosperity of the Territory and make our social conditions better and life more worth living.

Credit cannot be given here for all the ideas received from others, though the author would gladly acknowledge them. The literature of the subject has been consulted as fully as possible and where quoted full credit is given. But many men are working on the subject and a consideration of it is in the air. A prominent speaker* has gone so far as to express his belief that some form of government control was not only desirable and right but that it would be established in the near future. The author is heartily in sympathy with this idea and is sure it can be done with advantage to the stockman, the range, and all others concerned. With this idea in mind, the following statement of the case as found in New Mexico is submitted.

The total area of New Mexico is about 122,580 square miles, or something over 78½ millions of acres -- an area equal in extent to all the

*Dr. Gifford Pinchot, Chief Forester of the United States, at the Public Lands Convention, Denver, June 1907.

New England States, New York, and New Jersey combined; almost as large as Norway, the Philippines, or Italy and Switzerland combined; and more than half as large as France or Germany.

Data obtained from various sources show that the lands are apportioned approximately as follows:

1. Lands held under grants from the Mexican government and confirmed by the authorized U.S. land courts, about 9½ millions of acres.

2. Lands granted as subsidies to transcontinental railroads, about 4 millions of acres. Some of these holdings have been surrendered for lieu land scrip, and much of the land has been sold.

3. Lands granted to the Territory as an endowment for its schools, charitable, penal and other institutions, about 5 millions of acres. These lands are in charge of a territorial land commission and managed by a commissioner.

4. Lands held under patent from the U.S. government, obtained as homesteads, desert claims, mineral claims, etc., about 2½ millions of acres.

5. Lands included in forest reserves, Indian and military reservations, and reservations made for the reclamation service, in all about 8½ millions of acres.

6. Unappropriated or public lands, nearly 50 millions of acres.

It will be seen from the above that there is now open for entry in this Territory about 55 millions of acres of public land;* and that there are about 4½ millions of acres now in Indian and other kinds of reservations which may be and probably ultimately will be thrown open for settlement.

Geographically, New Mexico is to be considered as a high plateau about 350 miles square, sloping gradually from an elevation of about 6,000 feet above sea level on the northern end to about 3,500 feet at the southern end. It has been correctly spoken of as a part of the roof of the continent for it slopes gently eastward and westward from a north and south line which crosses it just west of the middle. Upon this plateau stand numerous masses and ridges of mountains, generally trending north and south, while through it and between the mountains wind the Rio Grande and Rio Pecos in relatively narrow valleys. Other smaller streams which rise in the mountains flow into these two, out of the Territory, or are lost in the dry sands of the mesas.

The mountains of the Territory are of two classes which I have chosen to speak of as "ridges" and "masses." By "ridges" are meant long, relatively narrow ranges, which stand out by themselves and are not of sufficient size and elevation to cause any large increase in precipitation. Such ridges are usually rocky and dry; they produce more forage than the plains; but much of it is composed of low bushes and scrubby trees. Few trees of any size grow upon such mountains; and

those which do grow are found on the upper, cooler slopes and in the less accessible canyons. Much of the greater number of named mountain ranges of the Territory are of this type, which is well exemplified by such ranges as the Florida Mountains, the Organ Mountains, or the Big Hatchet Mountains. The permanent watering places in such mountains consist of springs, seeps, and small streams rarely more than a mile long. Almost all the land upon which permanent water exists is patented and many such claims are occupied by the owners who have stock upon the surrounding public domain.

By "masses" of mountains I have attempted to characterize such areas as the Mogollon-Black Range area, the Sacramento-White Mountain region, or the Glorieta Mountains. Such areas consist of numerous more or less parallel ranges or high plateaus which are 25, 50, or more miles across and of even greater length. The valleys between the ridges are all at high elevations above the sea, and some of the peaks of such a mass usually extend above timber line. They are thus of such size and so high above the surrounding plains that they receive more precipitation, a goodly portion of which is snow. Such mountain masses are usually covered with timber from about the 5,500 feet contour, though the actual line at which timber begins is dependent to some degree upon the exposure. Above 6,000 to 6,500 feet altitude there is normally a good stand of coniferous timber, which extends on up to the timber line, found at from 11,000 to 11,500 feet in most places. The climatic conditions found in such mountainous areas are certainly not truly arid, though they are to some degree affected by the surrounding aridity.

There is very little absolutely true desert in the Territory and this consists mainly of relatively recent lava flows, gypsum dunes, and salt flats. A certain small part of the area consists of inaccessible rocky peaks upon which little grows.

The author has had occasion to talk with many of the stockmen of the Territory and with a number of the "oldest inhabitants," relative to the character and condition of the particular range that each was conversant with. The almost invariable reply to questions as to the past condition of a range was a statement that much damage has been done to the range by overstocking. They all say that years ago the ground was level enough to drive over with a wagon where it is now almost impassable for a horseman. They also claim that certain areas were once cut over for hay, while there is now little or nothing on them, much less a hay crop.

The second report of the Public Lands Commission shows that of 118 stockmen of New Mexico reporting upon the ranges they know, 102 believed that the carrying capacity of these ranges had diminished while only 16 reported that their ranges had increased in carrying capacity. Of this number, 69 believed the diminution was due to overstocking and 33 to drought. Since overstocking tends to produce drought, this second answer may be at least merely another way of saying that overstocking probably produced most of the loss in carrying capacity.

Attention has already been called to the value of range weeds as indicative of the degree and kind of overstocking to which a range has been subjected. Wherever the perennial grasses have been replaced by the annual 6-weeks' grasses, a certain degree of overstocking is indicated. This is apt to occur within a mile or so of the watering places and shows the need of more watering places. Arroyos and washes occupied by poppy thistle and wild tobacco as well as flats covered by the bee plant show ranges badly overstocked by cattle. The arroyos show where trails have been and where not only the grass but even the soil is gone as the result of the overstocking. Level areas with much of the Gutierrezia on it show some degree of the extinction of the grasses due to overstocking by sheep. Thus it is possible by looking at a range to tell how it has been treated. The number and kinds of range weeds, the kinds and abundance of grasses, the condition of the shrubbery, the amount and character of the erosion features, all taken together with an appreciation of the common or typical condition of the locality in question, tell the story of what the range has been and hence what it may be again by proper treatment.

Plants maintain their relations to each other, in any plant society, in the same way that animals do. Those plants best fitted to live in a given region become the dominant species by crowding the weaker species out. But the introduction of a new enemy to the dominant species may make it possible for another species of much less vigor to become the dominant one merely because its more powerful enemy has been displaced and itself allowed to grow and reproduce. Thus it always happens that a range which is overstocked, first loses its most valuable grasses, and the range becomes poorer; and finally, if the overstocking continues, everything which the stock will eat is destroyed and only thoseplants which they will not touch remain.

Overstocking with sheep is particularly exasperating, because it is so unnecessary, and is chargeable generally to pure laziness on the part of the herders. The sheep are held too long in one place -- so long that they kill everything which they can eat. Then when they move on there is nothing left to grow but the undesirable plants of the region. This may not be and usually is not done at once; but the habit of staying too long in one place, if persisted in, will ruin the best range, even if it has more than sufficient capacity to carry the stock upon it. A range so treated cannot recover when the stock are moved; because there is nothing but weeds left to recover; and once they are given possession, the valuable plants are crowded out.

In the opinion of the author, there is hardly an acre of range land in the Territory the carrying capacity of which may not be improved by a very small amount of effort and the use of ordinary judgment. Such improvement will amount to from 20 percent to over 100 percent on nearly any of the ranges; those which are now in the worst relative condition will, of course, respond with comparatively the greatest gains. There is but one way in which this desirable result may be obtained. Men will make the necessary effort to improve and protect the range only when they are absolutely guaranteed that whatever of benefit may come as the result of their efforts shall become their own gain. The whole matter may be summed up in the one expression, individual control and individual responsibility.

The practically uniform policy of the men getting the benefit of the range has been to get all they could in the shortest possible time without the least consideration for the range.

This method of management is explainable in one way only. The open range is public property; and being a gift to no one in particular and every citizen having a right to use it, he who takes all he can and takes it most quickly gets most of it. Since this gift is valuable, there is considerable competition to get it; and there is no longer enough to "go around" among those who wish to take it. The result of this struggle for the "eggs" of the "goose that laid the golden egg" is a marked decrease in the "egg" supply and sad inroads upon the physical vigor of the "goose."

The stockman cannot even protect the range from himself, because any improvement of his range is only an inducement for someone else to bring stock in upon it, and he thinks he had better put the extra stock on himself. Hence stockmen run all the stock on a given range which it will possibly carry at the time, with little thought for their own future and practically none for the future of the range. There is no one authorized to take care of the public range, and the present form of management has tended to make the beneficiary careless of the source from which he gets his livelihood, merely because he does not have legal control of the range he uses.

For those individuals who are carelessly or consciously ruining the ranges, there is no possibility of censure, much less of punishment; since they have no definite legal authority and consequently no definite responsibility.

The very greed of the users of the range and the periodic occurrence of dry seasons have been the only form of protection the ranges have had. The former causes overstocking and almost complete destruction of the forage crops. Then a dry season comes and the stock must be taken off the range or they will die off. Usually a large part does die; and while the stockman is recovering from the financial loss and getting the range restocked, the range is itself recovering to some extent from the effects of the previous overstocking. And this cycle of changes is continually kept up, but each round of change leaves an ever increasing permanent impairment of the range behind it.

"The only practical remedy is to give control of the range to the federal government. Such control would not only stop conflict, but would conserve the forage without stopping its use, as our experience with the National Forests has fully proved. It would likewise secure to the west the great benefits of legitimate fencing without interfering in the slightest with the settlement of the country -- on the contrary, while promoting the settlement of the country," says President Roosevelt. The President's recommendation as to a method of control is as definite and clear as his appreciation of the need of control. He proposes that the work of managing this area of something like 400,000,000 acres be placed in the hands of the Secretary of Agriculture, who shall be required to administer it in the way to subserve the best interests of the people who are most vitally concerned, i.e. those now occupying and using the public range in the vicinity of their own homes.

SUMMARY

INTRODUCTION. The thesis is proposed that it is a wise policy to conserve as far as possible the "material basis" of our national prosperity. The forage crop of our public lands is believed to be a part of this material basis and capable of being conserved.

AREA AND APPORTIONMENT. The total area of about 78½ millions of acres is apportioned in Mexican land grants, railroad land grants, Territorial land grants, forest, Indian, and Military reserves, patented lands, and public lands. More than 90 percent of these lands are now valuable for stockraising only and probably will always remain so.

TOPOGRAPHY. The salient topographical features of the Territory are set forth with their associated climatic conditions.

FORAGE PLANTS. The main grass societies are discussed and the distribution of each is shown on a map. These societies may for convenience be called (1) the Blue Grama society, (2) the Black Grama society, (3) the Colorado Bluestem society, (4) the Arizona Fescue society, (5) the Watergrass society, (6) the Saltgrass society. A number of other forage plants which are not grass-like are mentioned and the importance of each is noted.

WEEDS AND POISONOUS PLANTS. A number of weeds are characteristic of particular kinds of overstocked ranges; and a number of poisonous plants have been pointed out, while a few others remain to be studied.

CONDITION OF THE RANGE. Examination of the range shows it to be run down and not nearly as productive as it might be and as it once was.

THE CUMULATIVE EFFECTS OF OVERSTOCKING. Stock eat the valuable forage plants and leave the poor ones, thus giving the latter undue advantages in the struggle for existence. "Skinned" ranges do not hold water; the runoff is greater and more rapid, tending to increase dryness, the cutting away of soil, and the drying up of springs and water courses. A particular example of the effects of overstocking upon the drainage and erosion is given.

THE CARRYING CAPACITY. The average carrying capacity for the whole Territory obtained from the acreage and the average amount of stock, as well as it can be estimated, is approximately 35 acres per head per year (of cattle or equivalent). Detailed estimates for different parts of the Territory are given.

THE FINANCIAL VALUE OF THE RANGE. An estimate of the value of the range as obtained in several different ways shows that the prices ordinarily paid, viz: 2½¢ to 5¢ per acre per year, are about what the business will bear.

THE METHOD OF MANAGEMENT now in operation is detrimental to the business itself, to the ranges, and for both these reasons to all other industries of the Territory. The lack of legal control and responsibility are the principle characteristics of the present method or rather lack of management.

THE DESIRABILITY OF A BETTER SYSTEM OF CONTROL. An ideal system would place the land in the hands of as many individuals living upon it as it will support, and this ideal is the thing to be striven for. The important features to be included in any plan of management are to delegate legal control and impose responsibility upon the recipients. Both of these factors tend to the improvement of the range and therefore of the industry.

THE RESULTS OF CONTROL. A special case is cited in which control of a large area resulted in a 20 percent improvement of the range in the course of about three years.

THE REMEDY PROPOSED. It is proposed that the public grazing lands be placed under the control of a member of the cabinet and a system of permits or leases be established under rules adapted to each separate region and governed by the conditions obtaining in the region. The fees should be large enough to support the staff necessary to carry the plan into effect. Some of the objections to this plan are considered. Points which must be covered by the regulations are submitted. These are largely based upon the experience of others.

WHAT HAVE OTHERS DONE? Attention is called to a resume of the land laws of Texas by Dr. E. V. Coville, as well as the lease laws of Wyoming and the Northern Pacific Railroad Company. Our own Territorial policy is cited. The extended experience of the Australian colonies has proven that the plan is not only feasible but by far the best land policy yet proposed. The whole question resolves itself into the administration of a policy for the good of the many instead of for the few.

Wooton, E. O. 1915. Factors Affecting Range Management in New Mexico. USDA Bull. 211, 39 pp., illus.

Stock raising is more patently influenced by and dependent upon its physical environment than most other industries appear to be. The topographic and climatic conditions are fundamental, because they determine the kind and quantity of feed the animals must eat, the temperature and other extremes they must endure, and the various dangers which they must avoid.

The laws and customs of the region determine the character of the tenure and control of the land which produces the feed upon which the animals subsist. They are but the expression of the public opinion that warrants the existence of that industry in that place. And not less important, but probably less often considered, is the relation which the business bears to other industries in operation in the same region. From this standpoint, the industry is to be considered as in a certain stage of development toward a better and more complex adjustment among all industries, and a statement of its present condition must be taken as in the nature of a report of progress. It is not what it once was, nor yet what it will be.

New Mexico is almost square in outline, being about 350 miles long from north to south, nearly as wide at the southern end, and somewhat narrower along the northern boundary. Only the southern boundary is a broken line. The State consists essentially of a high, arched plateau, the axis of the arch being near the middle and running north and south, the northern end being higher than the southern. This plateau is about 7,000 feet above sea level at its highest point on the northern boundary line and drops to about 3,500 feet at its southern end.

Precipitation is everywhere relatively small in amount in New Mexico. On the plains of the southern part of the State and in all of the river valleys outside of the mountains, it is always scanty. In the mountains at altitudes of 5,500 feet or more, it is more abundant; but even in the more moist regions, the amount of water that falls during the year is rarely equal to that which is common in the humid regions farther east.

It has been said that there are but two seasons in the southern valleys, summer and late fall; and the longer of these is summer. The summer rains usually occur as rather violent local showers of short duration. The water falls from clouds that are high above the earth, and the air next to the ground may be relatively dry; in fact, it is not infrequent to see small, high clouds that are evidently producing some rain, but the water evaporates at a lower level and never reaches the ground.

The average precipitation of any station in the State also seems to be in some way dependent upon its distance from the southeast corner. If localities having the same altitude be considered, it appears that

those in the southeastern corner have the greatest average rainfall and that this rainfall gradually diminishes as one goes west and north. This fact would seem to suggest that the source of the moisture lies to the southeast, possibly the Gulf of Mexico.

It will thus be seen that there is a range from the lowest amount recorded, 3.49 inches, to almost five times that amount, 17.09 inches, the highest record. For one period of ten consecutive years the total annual precipitation was each year below the average quoted above, and periods of three to five years in which the annual rainfall is two-thirds of the normal or less have occurred three times within the time for which the observations have been made.

Snow occurs at some time every winter at all points in the State. At the lower levels the occurrence is rare and the quantity that falls is small, nor does it lie long. In the higher mountains of the northern part of the State, considerable of the precipitation comes as snow; and in favorable locations it drifts and lies for most of the winter. From such regions, stock are excluded for at least part of the year.

The most characteristic peculiarity of the temperature and one which applies at all points in the State is the great range which occurs yearly, monthly, and daily. A daily range of 45° F. is not uncommon, and one of 30° or more may be said to be almost the rule. This condition is, of course, due to the altitude and the lack of moisture in the air.

When it is remembered that the months of spring and early summer are usually quite dry as well as cold at night, the late starting of the native plants is explained. At high elevations the growing season is short, and above 8,500 feet frosts are recorded for almost every month in the year.

Wind motion is an important climatic factor throughout the State. The air is nearly always dry and frequently very dry, and the wind blows much of the time. The spring is apt to be particularly windy, and the most violent sand storms are usually accompanied by low humidity and consequent rapid evaporation. Many young seedlings are dried out or cut off by the sand during these windstorms, and much damage is done to cultivated crops even in the irrigated fields.

Notwithstanding the various unfavorable climatic conditions that plants must be able to endure, there is a covering of vegetation of some kind practically all over the State except locally in spots where the soil is of drifting sand or so alkaline as to kill plants, or on the flat playas that are subject to occasional inundation, or on exposed rocky surfaces where there is little or no soil. This vegetation is frequently very scanty and scattered, often scrubby and spiny, showing in many ways its adaptation to a scanty supply of water. Many of the plants are valueless as forage, but many times more are good for this purpose, and when examined in detail the wonder grows that so many and not so few are usable by stock at one time or another.

Here any kind of management that permits or assists in the waste of water in any way tends in the long run to the desiccation of the region. Hence, any practice that increases the rapidity or amount of superficial runoff or increases the evaporation of water (other than that which passes through the bodies of growing plants) makes for the gradual drying out and increased sterility of the region. These processes are cumulative, and regions that are easily habitable under one kind of treatment may be gradually changed to desert wastes by another procedure which, to the careless observer, does not seem materially different from the first.

Speaking very generally, the soils of most localities in the State have been formed almost entirely by the disintegration of the underlying or nearby rocks and necessarily have the chemical composition arising from the breaking up of these rocks, mechanical or chemical, or both. The soils of the river valleys have been transported considerable distances and the particles assorted to size by the action of the water. They consist mostly of sand or adobe and are uniform in character and depth only for very short distances, because of the great variations in the volume and velocity of the waters of the streams that have deposited them.

The soils of the larger and higher mountains, wherever they occur, are mostly a rather rich loam, due to the nearly complete chemical decomposition of the rocks, and contain considerable humus derived from the vegetation of such regions. The foothills of the mountains are mostly flanked by talus slopes and outwash plains composed of partially disintegrated rock particles of various sizes, forming gravelly ridges and slopes in which proper soil particles constitute only a small part of the volume.

The soils of the plains and bottoms are largely windblown sand or loess. In the bottoms of the basins such soils are sometimes deep, but mostly they form only a thin layer.

New Mexico has large areas of cheap land upon which these products may be grown and which are not well suited to any other business.

Naturally they have been occupied by stockmen, but the difficulty of obtaining and maintaining control of the land has materially retarded the natural growth of the industry, and today this lack of legalized control of the land is not only reducing the output and rendering the business precarious, but is causing marked deterioration of the range itself, besides causing great and frequent losses of valuable property, to say nothing of the suffering of thousands of animals that die of starvation.

A careful examination into the conditions, laws, and customs now controlling the business is here attempted.

Under another heading attention has been called to the relative areas of land held under legal tenure of one kind or another. It is of importance to know how possession of the Government lands is maintained and to understand how this form of tenure affects the stock-raising industry.

It must be kept in mind that only such land to which the claimant has title or right or is in process of obtaining such title by the method prescribed by the land laws may be inclosed with a fence. To this group belong (1) the patented homesteads, desert claims, timber claims, lieu-land selections, or all Government lands that have been filed upon according to some existing land law; (2) all railroad land grants which have not been exchanged for lieu-land scrip; (3) all the lands included in the old Mexican land grants that have been confirmed by the courts; (4) the State lands which have been given to the State by the National Government as an endowment for its educational, penal, and charitable institutions, and; (5) land held in small areas under mineral claims, such areas being held from one year to the next by performing the assessment work each year. It goes without saying that all such lands may be fenced and controlled according to the will of the claimants.

All other lands, not including various reservations like National Forests, Indian reservations, etc., are Government lands and according to the rulings of the General Land Office may not be inclosed with a fence. They are public property and in the sight of the law may be used by everybody in general and nobody in particular.

It was assumed when the existing land laws were made that all land was about equally good and that 160 acres of it was amply sufficient for the support of one man's family; that if he wanted any of it he might have that much and welcome; and that all of it would ultimately be given by the Government to its individual citizens.

It has since been learned that much of the land will not support a family upon 160 acres, but that in certain places from 20 to 50 times that area is necessary. Of course, the original lawmakers assumed such land to be desert and therefore valueless. It has a certain value as pasture land, however; and in order that its best use may be secured, it is necessary that it should be used to some degree in severalty instead of in common. It being impossible to obtain legal control of it in bodies of sufficient size to carry on stock raising with profit, men were forced to control it some other way or not use it.

The need of stock water is as great as that of stock feed, and the pioneers in the stock business at once perceived that the water could be controlled. So today throughout the region the permanent watering places are all held under some kind of legal right, and it is through the control of the water that the range is controlled.

This set of conditions gave rise to the custom that men should use and claim as their own the pasture lands surrounding their watering places. Whenever a conflict of interests arose, the men concerned had to settle

it among themselves. Community of interests and the desire for an amicable agreement have led to a set of customs that have the force of unwritten laws. These differ to some extent in different localities, mainly because of local conditions, but the basal principles, being dependent upon the requirements of the business itself, are quite uniform.

On an open range it is, of course, necessary to have all water open, and cattle and horses go where they will to drink, though they are generally "located" in some particular region. It is the common custom to allow all stock of whatever ownership to water at any watering place, and the man who would exclude any of his neighbors' stock from his water troughs would be ostracized. But this necessity of the business makes it possible for the stingy or thievish man to "edge in" on every other owner in his district. He "develops" water at a certain place, but not in sufficient quantity to supply the number of animals he puts upon the range. It follows that his animals get some of their water from his neighbors, and water costs money in the range country at any place. Thus, the small man is a thorn in the side, especially of the large owner who has a first-class equipment. The latter may retaliate by throwing large numbers of his stock into the small man's range long enough to eat it out in a short time or by instituting legal proceedings on trumped-up charges, thereby causing the small man loss of time and unnecessary expenditure of money. These are but a few of the more patent of the competitive methods in use among cattlemen, and another similar set is to be found among the large and small sheepmen.

The battles between the sheep and cattle industries have been told time and again. The sheepman has the advantage in most respects. His stock are herded all the time; they can be held on any spot as long as he desires; if held long enough, they will practically obliterate the vegetation on such an area; they require much less water than cattle and with green succulent feed may go for long periods without any water at all; they may be driven in almost any place where other stock can go. He is thus able to drive over a cattleman's range and leave desolation in his wake if he wants to; and he may do this, too, without over-stepping his legal rights.

For convenience in handling the sheep at night, the herders build brush corrals. These corrals burn readily after the brush is dry. When not in a corral, sheep may easily be stampeded and scattered at night. A herder's camp fire at night is a conspicuous target, but the immediate vicinity is very unsafe when rifle practice at such target is going on, and a band of sheep without a herder is soon lost. Such gentle hints as any of these may be taken to indicate to the sheepman that it is time for him to move on.

Whatever may be said of the undesirability of weeds on a range, there is one thing to be said in their favor. Any vegetable covering in an arid region is better than none, since such a covering prevents to some degree the removal of the soil, and any plant association occupying an area is to be looked upon as merely one stage in the production of that ultimate assemblage of plants which is best adapted to that place and its conditions.

To the observer from a humid climate, perhaps no one characteristic of the arid regions of the Southwest is so startling as the evidence on all sides of the forceful action of water as an erosive agent. And this in a land where water is the one thing that is everywhere lacking.

But the reason is patent after a summer in the region, and the conditions are common to all arid countries of high relief. The erosive effects that one sees so plainly are the resultant of several factors. During the warm weather, the only season of the year in which large volumes of moist air are brought into the region, the air next to the ground is always warm and therefore relatively dry. Hence, rain occurs only when masses of humid air are forced into the cold upper strata. Such conditions arise only locally and produce showers of restricted size, but such showers are mostly torrential in character, a large amount of water falling on a restricted area in a short time.

Let such a downpour occur on what seems to be a flat plain, and in a few minutes the lower levels are flooded and the roadbed of any obstructing railroad is apt to suffer severely. Thus, we are forever hearing of railroad washouts in a region that is called a desert and is wanting governmental irrigation systems established.

The land is but sparsely covered with any kind of vegetation and there is little to obstruct the runoff. The gradient is high at almost any place. Add to this the fact that the soil has been loosened by daily expansion and nightly contraction, due to large diurnal variations of temperature, and the conditions for maximum efficiency of the erosive agent are supplied; and the consequences are not only not singular but were to be expected instead of wondered at.

The factor which more than anything else tends to prevent the same kind of results in a humid region on an even large scale is the protective cover of vegetation everywhere abundant, and no one factor is so efficacious in producing rapid erosion on the arid grazing lands as the more or less complete removal of their already scanty cover of plants by overstocking.

An experienced and successful cattleman in the southern part of New Mexico, commenting to the writer not long ago, said:

I can better afford to take the $2,500 loss of stock which I know I will have when the dry years come than to take my stock off my range and try to save the grass which I know I will need in those dry years. I hold my range now only by having my stock on it. If I take my stock off, someone else will take my range, and I can afford to lose the stock better than lose the range.

Every stockman using Government range lands is forced into this kind of action whether he be astute enough to have reasoned it out or not. Yet these same lands under a better type of management (possible only under legalized control) would carry safely all the time more and better stock than they now carry with such uncertainty.

It is a well-known botanical fact that in order for ordinary green plants to grow they must have leaves, since the food from which new growth is made is elaborated mostly in the leaves. This point has been emphasized by various writers, but no definite data as to the exact effect of pasturage upon the quantity of feed produced have been obtained till recently. Studies carried on by Drs. Briggs and Shantz have given some very definite data for alfalfa. From their work it appears probable that whenever range land is closely pastured during the growing season its total productivity is automatically reduced approximately two-thirds or possibly more. Or, stated generally, close grazing during the growing season reduces the carrying capacity about two-thirds.

One way to diminish this effect is to divide the range into a number of relatively small pastures and give each pasture a rest in turn. Each pasture must be given as long a time to grow its crop as is possible, keeping in mind all the time the fact that the stock must grow as rapidly as possible. It is probably better to put a large number of animals on a relatively small acreage for a short time, thus giving the plants a long period of growth. This procedure makes a larger number of watering places necessary.

Subdividing the range is beneficial in another way. In many places there are areas that produce forage which is good feed only while it is green. On other nearby areas forage which cures standing occurs. The latter is the natural winter feed of the region, but these plants are usually preferred by animals while they are green. Thus, if the animals are allowed to range freely and select their feed, they eat the winter feed in the summer time. From the standpoint of sustenance, the summer feed is all right in the summer but poor in the winter. Hence, good management requires that it be eaten while at its best. Similarly, the winter feed should be saved till the winter time. Without fences such management is impossible; and the selective action of the stock is always operating to destroy the best feed on the range, for they always graze it more closely, even when the range is properly stocked.

In New Mexico there is almost everywhere sufficient stock water to supply all the animals which the range will carry, and in many places quite a little more could be developed. This is one of the factors which have made overstocking not only possible but unavoidable under the present system of tenure.

No other one factor is so important as the abundance of good, clean water, well distributed over the ranch, and there are relatively few ranches that now have the water so well distributed that the range may be uniformly grazed. Stock mostly have to go too far for water, with the result that much grass is trampled out around the watering places; and the range is apt to be cut up by trails that ultimately become arroyos. And it is equally true that much more water could be developed upon most ranges, a procedure that would materially help the business. But under the present uncertainty of tenure of the range lands, such expenditures are not warranted.

Very little feeding of range stock has been done in New Mexico for any purpose whatever, and it is still a common practice to let animals die of starvation if there is not sufficient feed on the range to maintain them. Aside from the humanitarian argument, this is really very poor business, with meat at its present price.